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Thesis

A THIRTY-SIX WEEKS COURSE IN MECHANICAL DRAWING FOR HIGH SCHOOLS
with
LESSON ANALYSES

Submitted by

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In partial fulfillment of requirements for
the degree of Master of Education

1946

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INTRODUCTION

This thesis is a carefully constructed plan for a practical thirty-six weeks course in mechanical drawing with general background information drawn up in unit form and intended for mimeographing and distributions to the students; a chart showing lesson sequence and course progress; and lessons with their respective drawings and related information.

Part One covers general information such as history of mechanical drawing and history of materials.

Part Two covers technical information, such as elements of drafting, and the standards accepted by engineers, educational authorities in this field, and the American Standards Association.

The distribution of the prepared material in parts one and two at the beginning of the course for home reading gives the student background knowledge which will enable him to grasp more clearly, specific points touched on in each lesson under related drawing knowledge.

To determine the fundamentals for this course of study, drafting books, pamphlets and current publications were examined for content in general use in mechanical drawing. A list of courses, used by other schools was studied and classes in mechanical drawing and engineers

in local industries were visited.

Due to the rapid changes in national affairs since 1941, a knowledge of, or ability in the use of mechanical drawing has been a great asset to anyone in the Armed Services and in industry. The uneveness of preparation in mechanical drawing in boys from different communities has been quite evident and also the resulting handicap in the progress of the pupils in their employment.
In most high schools mechanical drawing is an elective subject offered for one year only, and its presentation has not changed sufficiently over the years to keep pace with manufacturing. This course has been planned in a unitary fashion to present all material essential in the present day in lessons condensed so that the complete fundamentals of mechanical drawing can still be covered in a year, but in a much more comprehensive and timely fashion than has been customary in the past.

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PART I

Chapters I-XVII Units 1-17

CHAPTER 1

Unit 1: GENERAL INFORMATION

A PERSONAL WORD to the Pupils.__ When you start out to study any subject, no matter what it is, the important thing is to START RIGHT. Get the first principles fixed in your mind, and the rest will be easy.

The first few lessons may seem easy to you, because you may already have an understanding of mechanical drawing. Eventually the larger, more detailed drawings will become just as clear to you after you have spent time in the mastery of the units that follow.

Master each lesson as you come to it, especially basic principles. Gradually the simple and comparatively easy drawings will give way to larger complicated drawings which you will be able to handle without difficulty if you have mastered each lesson leading up to them.

OUR AIM.__ We would like to have this room one in which there is congenial CO-OPERATION.

A room where you and I work in HARMONY, and with REGARD for each and all.

A room that is doing GOOD WORK.

A room where good work is APPRECIATED.

A room where each and every student has OPPORTUNITY to make the most of his ability.

OUR MOTTO.— BE BUSY AND BE YOURSELF.

DEFINITION OF MECHANICAL DRAWING.— mechanical drawing is a graphic language, world-wide in use, which expresses ideas and data necessary for the construction of objects in use, from past centuries to date.

HISTORY OF MECHANICAL DRAWING.— While mechanical drawing first takes its place in history in the year 1475, it is a fact that working drawings were used long before that by the Romans in planning their public buildings, bridges, aqueducts and roads; many of which are still standing. Before the Romans, drawings were made by ancient peoples in designing tombs and temples and by the Greeks in planning temples and monuments.

As you know, the Middle Ages saw the development and expansion of the Guild System under which handicrafts were learned and practiced by members and apprentices. With the discovery by Watts that steam could be harnessed and made to supply power and machines designed to make use of that power, the Guild

System gave way to the factory and handiwork was superceded by machine production.

With the development of the Industrial Revolution there grew an intense interest in facts of a mechanical and scientific nature in Great Britain. The Mechanics' Institute movement was the outcome. Schools and societies sprang up rapidly, offering instruction in mathematics, science, and drawing, both industrial and architectural.

In America, at about the same time, a similar movement took place, first in the form of Mechanics' Institutes and Lyceums, later developing into such schools as the Franklin Institute, Rennselaer Polytechnic Institute, Worcester Polytechnic Institute, and others.

Since the beginning of the Industrial Revolution, transportation has advanced from its early stages of pack carrier and ox team to canal boat, steamship, railroad, motor vehicle and airplane. Agriculture has been revolutionized by the development of machines for tilling the soil and reaping the harvests. Communication has been speeded up by the invention of the wireless, telephone, and radio.

Articles of ordinary and extraordinary use are now produced in large volume at low cost; thanks again to the development of machines for use in place of the old hand labor of the Guild System.

Today we are the most highly mechanized nation in the world. With the increase in the use and development of machines has come an unusual demand for men trained in mechanical drawing.

SCOPE OF SUBJECT.— The objectives of this course in Mechanical Drawing are general and specific. The course is cultural in that it emphasizes training in accuracy, concentration, neatness and power of visualizing. It is vocational in that the training in skills can be directly applied in industrial drafting establishments.

CONDUCT.— Each student is expected to be at his drafting table on time, to remain there and attend to his own work, which is assigned. Cleaning time will start three minutes before the end of the period.

Each student is expected to return to its proper place, all equipment. If a student has occasion to

leave the room, he should get permission and a pass slip will be issued. Those who wish to wash their hands will find soap and towels at the wash stand.

ATTENDANCE.— Attendance will be taken at the beginning of the class. Any student who is not at his table will be marked absent. Students who enter tardy will have to present a tardy slip. All absence should be made up within one week following return, Students should make this arrangement.

CLASS INSTRUCTION.— As part of the course, class instruction will be given from time to time. The textbook and drafting standard text will be used as reference. As work progresses, personal instruction, suggestions and criticisms will be offered to help the student in his work.

COMPLETED WORK.— No drawing is to be removed from the drawing board until checked.

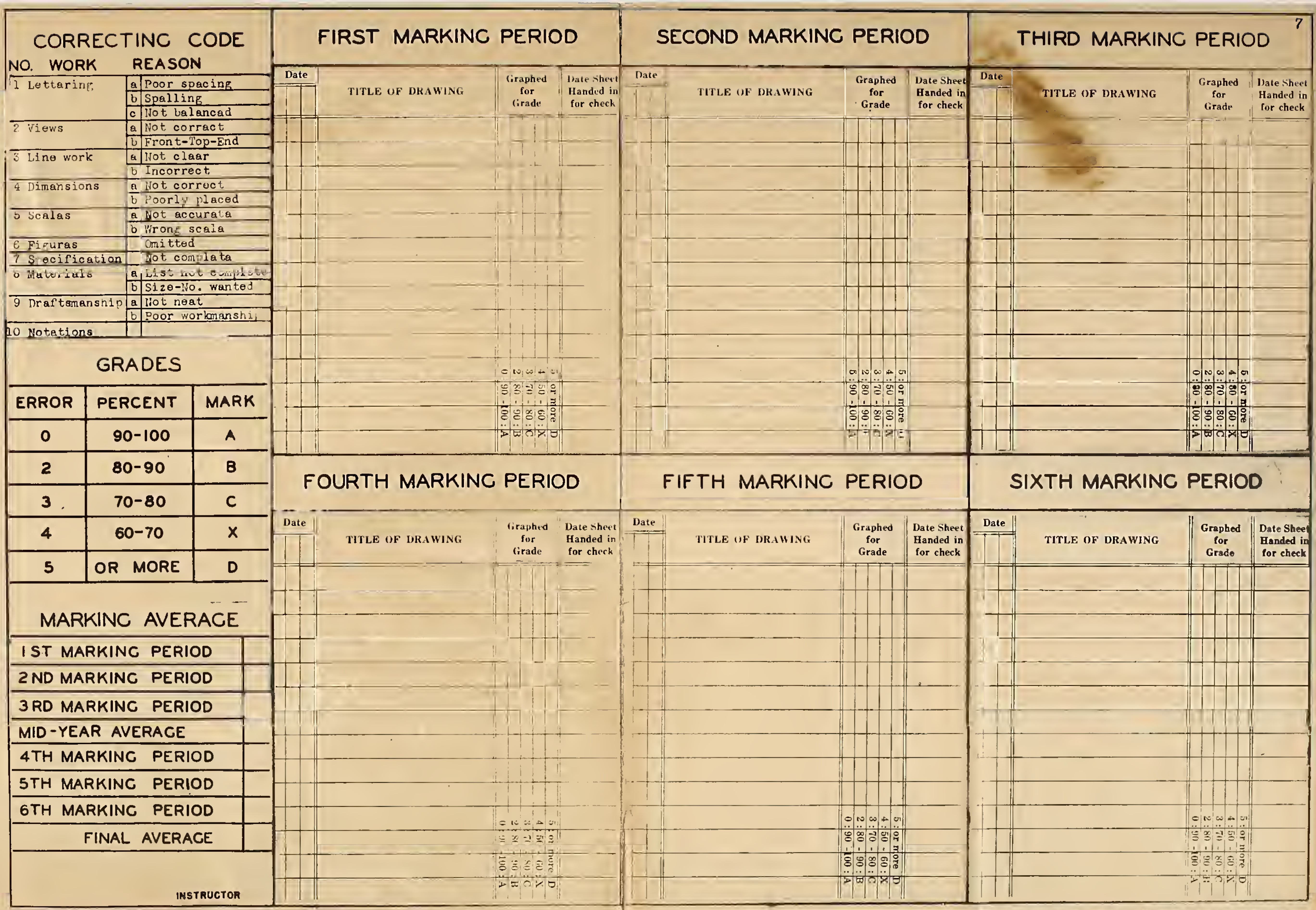
When work is completed to the student's best ability, a careful inspection is made. The work is gone over with the student; the good features are pointed out as well as those which are not good. When the drawing is removed from the board it should be placed

in the cabinet which has been assigned

GRADES.— I believe every student should know at all times just how he stands in class.

With mechanical drawing progress graphs such as follows in figure 1, the student places his own evaluation upon himself.

The corrections on the papers returned to him reflect the quality and quantity of the work done.



CORRECTING CODE

NO. WORK		REASON
1 Lettering	a	Poor spacing
	b	Spelling
	c	Not balanced
2 Views	a	Not correct
	b	Front-Top-End
3 Line work	a	Not clear
	b	Incorrect
4 Dimensions	a	Not correct
	b	Poorly placed
5 Scales	a	Not accurate
	b	Wrong scale
6 Figures		Omitted
7 Specification		Not complete
8 Materials	a	List not complete
	b	Size-No. wanted
9 Draftsmanship	a	Not neat
	b	Poor workmanshi
10 Notations		

GRADES

ERROR	PERCENT	MARK
0	90-100	A
2	80-90	B
3	70-80	C
4	60-70	X
5	OR MORE	D

MARKING AVERAGE

1ST MARKING PERIOD	
2ND MARKING PERIOD	
3RD MARKING PERIOD	
MID-YEAR AVERAGE	
4TH MARKING PERIOD	
5TH MARKING PERIOD	
6TH MARKING PERIOD	
FINAL AVERAGE	

INSTRUCTOR

FIRST MARKING PERIOD

Date	TITLE OF DRAWING	Graphed for Grade	Date Sheet Handed in for check

0 : 90 - 100 : A
2 : 80 - 90 : B
3 : 70 - 80 : C
4 : 50 - 60 : X
5 : or more D

SECOND MARKING PERIOD

Date	TITLE OF DRAWING	Graphed for Grade	Date Sheet Handed in for check

0 : 90 - 100 : A
2 : 80 - 90 : B
3 : 70 - 80 : C
4 : 50 - 60 : X
5 : or more D

THIRD MARKING PERIOD

Date	TITLE OF DRAWING	Graphed for Grade	Date Sheet Handed in for check

0 : 90 - 100 : A
2 : 80 - 90 : B
3 : 70 - 80 : C
4 : 50 - 60 : X
5 : or more D

FOURTH MARKING PERIOD

Date	TITLE OF DRAWING	Graphed for Grade	Date Sheet Handed in for check

0 : 90 - 100 : A
2 : 80 - 90 : B
3 : 70 - 80 : C
4 : 50 - 60 : X
5 : or more D

FIFTH MARKING PERIOD

Date	TITLE OF DRAWING	Graphed for Grade	Date Sheet Handed in for check

0 : 90 - 100 : A
2 : 80 - 90 : B
3 : 70 - 80 : C
4 : 50 - 60 : X
5 : or more D

SIXTH MARKING PERIOD

Date	TITLE OF DRAWING	Graphed for Grade	Date Sheet Handed in for check

0 : 90 - 100 : A
2 : 80 - 90 : B
3 : 70 - 80 : C
4 : 50 - 60 : X
5 : or more D

Figure 1. Drawing Progress Graph

CHAPTER II

Unit 2: HISTORY OF LEAD PENCIL

In the lesson on lettering you will learn that prehistoric men were drawing on the walls of their caves. Yet, it was not until 371 years ago, when a picture of a wooden tube holding a piece of graphite appeared that mention was ever made of anything which might be called a lead pencil.

About 1400, graphite, the main ingredient of the modern pencil, first appeared, and for a long time was used without covering.

In the reign of James I of England,hawkers on the streets of London sold markers of black graphite lead. Most of the graphite came from a mine discovered at Borrowdale, England. It was of such unusual purity that it was used in its natural state for writing.

In the 17th century, graphite was covered in various ways. It was wound with a string which was unwound as the lead was used. It was held in a metal holder, or "Port-crayon" as it was called. It was pushed into quills and put into tubes. Finally around 1686, a means of putting graphite between strips of wood was discovered and the present day physical form of the pencil arrived. But along with the changing form of the

pencil another development was taking place which held back the evolution of our present lead pencil for over 100 years. The Bottowdale mine, source of practically all the graphite used, was being worked out. The price rose to $7.50 per pound, and export from England was finally prohibited. A search was made everywhere for another mine, but none was found which contained graphite as pure as that from Borrowdale, which could be used in its natural state. First it was necessary to remove impurities by refining and because the result was a powder, a means to hold together this powdered graphite had to be discovered.

Not until 1795, was success achieved. In that year a Frenchman, Jacques Conte, started the modern pencil industry by using clay as a binder. It was this discovery that also made possible, by the use of different proportions of clay and graphite, variations in degrees of hardness, unknown until then.

The manufacturing of lead pencils today is based on the old French method, although there have been many improvements in technique. Two main steps are making the lead and inserting it in a suitable wood cover. To make

pencil lead, the clay and graphite are refined, pulverized and mixed together into a doughy mess. This is done by grinding. Heavy flint stones in a mill turn over and over, crushing and mixing the clay and graphite together. Good as this method is, there are two disadvantages, the particles are comparatively large and there is danger of chips of flint becoming mixed with the ingredients. Many American pencil manufacturing companies, therefore, divised a chemical method, known as the Colloidal Process, to break the graphite into particles so small they go through filter paper so fine they rival the smoothest face powder. A more scientific mixing is then obtained, and a smoother more uniform lead is possible than by the grinding method.

After mixing, the lead is forced under pressure through the Jewel dies and shaped to proper thickness, then cut to size, baked and dipped in wax. It is then made ready to be put into wood by the following five steps:

Step
1. The leads are placed in grooved slats of wood which are of pencil length, from 4 to 7 pencils in width and a half pencil thick.

Step
2. Another grooved slat is covered with glue and put over the one containing the lead. The two are then pressed together under hydraulic pressure

into a pencil block. The grooves of two slats fit perfectly around the individual leads, thereby giving the impression, to the unitiated, that a pencil is made by drilling a hole in the wood and inserting the lead.

Step
3. After a period of drying, the block is passed through a machine which cuts between the grooves thereby dividing and shaping the block into rough pencils.

Step
4. The pencils are sandpapered to give a smooth finish and are then varnished, polished and stamped with the name of the pencil and the degree of hardness. Various materials are used for stamping. For most pencil markings, 22 karat gold is employed.

Step
5. If the pencil takes a tip and rubber, they are put on by an automatic machine that shaves the end of the pencil, pinches on the brass tip and inserts the rubber, all in one operation.

This completes the outline of the actual manufacturing processes. There are many other things, however, which enter into the production of a quality product. With good pencils, inspection takes place all through the course of manufacturing; careful tests are made to be sure that the grading is exactly what it should be, that the finish is just right, and that everything about the process goes toward producing the world's finest drawing instrument.

WHERE SOME OF THE INGREDIENTS OFTHE PENCIL COME FROM.

Materials		Locations
Cedar	--	Tennessee and California
Gold	--	Nevada and South Africa
Rubber	--	U. S. Synthetic and Straits Settlement
Clay	--	Georgia and England
Graphite	--	Ceylon and Mexico
Wax	--	Brazil
Sulphur	--	Texas
Pumice	--	Italy
Copper	--	Michigan and Montana
Zinc	--	New Jersey

GUIDE FOR PENCIL USE, TECHNICAL. [1]

Architectural Draftsmen:
Drawing to scale--3B, 2B, B,HB, F, H. 2H, 3H, 4H.
Construction lines--9H
Rendering--4B, 3B, 2B, B, HB.

Engineering Draftsmen:
Drawing to scale--HB to 6H.
Lettering, field notes, detailing--2H, 3H.
Line work on drawings, including cross, longitudinal and other sections--F to 4H.

Artists: 6B to 6H
Builders: 2B, HB, F, H, 2H
Designers: 3B to 4H
Photographers: 6B, 5B, 2B, HB, F, H, 2H
Stone Cutters: 7H, 8H, 9H
Commercial Draftsmen and Designers: HB to 9H
Commercial Artist: 3B to HB
Engravers: HB to 6H
Jewelers: 9H
Layout Men: 6B to HB
Woodworking: HB

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[1] Dixon Crucible Co., Jersey City, N. J. *Typhonite Eldorado*. Booklet 1942

CHAPTER III

UNIT 3: HISTORY OF PAPER

The first known writing was done on stones, ivory, bark, and any substance that had a flat surface. In ancient Babylonia an immense commerce was carried on in which all transactions were recorded by indenting characters on the clay bricks which were afterwards baked. For filing and reference these records proved far from practical but it was not until 2,500 and 2,000 B.C. that the ancient Egyptians learned how to make an easily handled writing material from the papyrus plant which grew along the river Nile. It is from this that we get our word "Paper".

The stalk of the papyrus was split into thin strips which, were laid flat with edges touching. Another layer was placed at right angles over the first, both were pounded together, then smoothed with a stone. The first real paper, that is a sheet composed of fibers "felted" together, was made by the Chinese about 100 A.D. This process was kept secret for nearly 600 years. It was not until the Mohammedan Arabs conquered Samarkand (western Asia) in 704 that it became known in the western world. The Moors carried the process into Spain, and by

the end of the twelfth century paper makers were active there and in Italy. From these countries knowledge of paper making spread to the rest of Europe.

The first mill in America was built in 1690 near Philadelphia. All paper at that time was made by hand, and hemp, linen and cotton rags formed the only raw material available. The rags were reduced to pulp ny the action of a stamping mills, usually driven by a water wheel. The pulp was then placed in a vat and highly diluted with water. A skilled workman dipped a quantity of pulp and water out of the vat by means of a form with wire screen bottom and a removable frame, or deckle, around it. With an expert twist or shake the workman felted the fibers as the water drained through the wire screen, leaving the fibers matted on top of the screen. The deckle frame was next removed, the screen with the wet fibers turned upside down and the sheet of fibers pulled off on to a piece of felt. Another felt was placed on top and the performance repeated. When the pile of felts and paper was about a foot high as much water as possible was removed by pressure. The separate sheets of paper were then hung over poles to dry.

Naturally paper production under this process was limited, and it was also very expensive, so that writing

materials and books were scarce and, because of their cost, out of the reach of the average person. In 1799, a Frenchman, Lois Roberts, conceived the notion of making paper on a movable, endless wire screen. He sold his patents in England to Henry and Sealy Foundrinier who developed the principle and in 1804 constructed the first practical papermaking machine. With the invention of the paper machine, paper production was very materially increased, and many new uses were found for it which heretofore had been prohibited by its high price. Soon, however, the supply of rags became very scarce, and appeals were made to the inventors of all countries to find a substitute raw material.

In 1841, Gottfried Keller of Saxony invented the process of making paper from a pulp made by mechanically grinding wood against a revolving stone. Today drawing paper is made largely from fibers produced in this way. The chemical composition of the wood is not changed in the grinding process, and as a result, paper made from mechanical pulp is subject to the same decomposition as the wood itself.

In 1867, Benjamin Tilghman of Philadelphia invented and patented a chemical process of separating the fibers of wood from the other products of the growth of the

tree. Though it was many years before the imperfections of this process were overcome and it became commercially practical, toward the end of the nineteenth century, chemical wood pulp began to be used extensively in the paper industry. There are a number of chemical methods of producing wood pulp. These are the sulphate process, which produces pulp suitable for drawing papers; the soda process, used extensively for book paper; the sulphite process. The sulphite process (named from calcium bisulphite the cooking liquor used) is an elaborate treatment by which the resinous and ligneous substances in the wood are dissolved, leaving the pure cellulose fibers for paper making.

It is this process that has been developed to a high degree assuring uniform drawing papers. Selected spruce trees furnish the fiber material and are cut into logs four feet long, and shipped to the mill. The spruce logs are carefully barked by being rolled over each other while streams of water play on them to loosen the bark and wash it away. Inspectors watch for logs not completely barked and returned them through barking process. After barking, the logs are washed free of dirt and remaining pieces of bark. At this stage, any knots are removed by special boring machines. The logs are then

reduced to chips, which are screened to free them of chip dust. The larger chips are broken up, with the result that chips of very uniform size are stored until ready to be "digested."

Acid resisting, brick-lined tanks, 50 feet high, called "digesters," are filled with the chips. Then the cooking liquor, calcium bisulphite, is pumped in, and under controlled temperature and pressure, is circulated through the mass of chips by means of a pump. After having been thoroughly cleaned, the fibers are subjected to the bleaching action of chloride of lime, which turns the pulp to a beautiful shade of white. The pulp is now placed in "beaters" for treatment essential to the character of paper to be made. A beater consists of a tub partly divided by a partition, on one side of which a large roll revolves rapidly. The outside of the beater roll has bars of bronze spaced at regular intervals. The "roll" rotates above a "bed plate" of similar bars. As the roll turns, the fibers are brushed together between the blades and reduced in length. The sides and ends of the minute fibers become frayed so that they will lock together or "felt" more strongly in the paper.

Certain essentials, such as the necessary colors, are added to the pulp while it is being beaten. A glue-like substance called "size" is also added to close up the hollow straw-like fibers, so that when the sheet is written upon the pencil or ink will not penetrate, but will dry on the surface of the paper. After beating, the "stock" is passed through Jordan refining engines, having bronze blades somewhat similar to the beater.

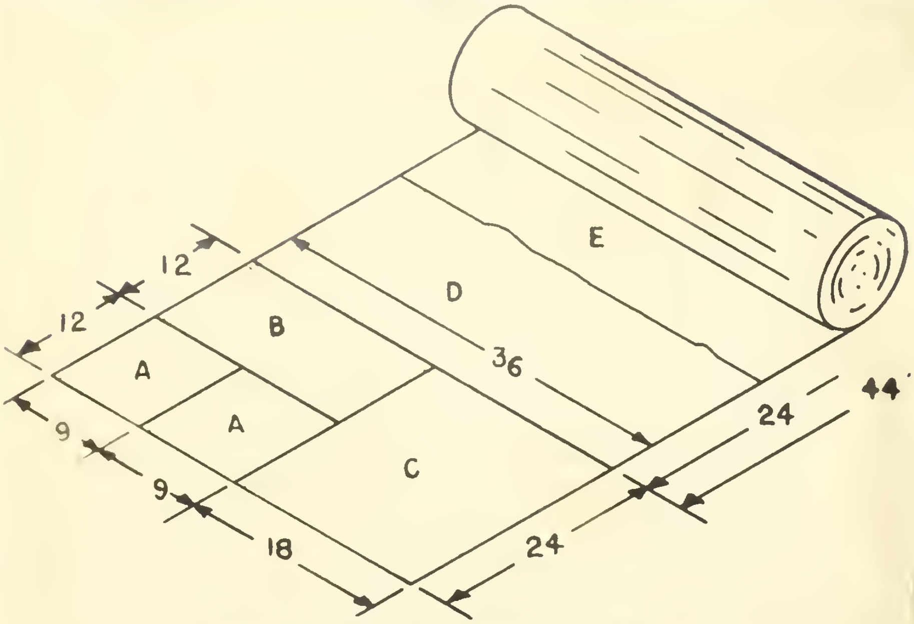
Then the pulp passes through a "stock sheet" or storage vat to the paper-making machine called the "Fourdrinier". This machine is named after the man who, you will recall, developed it over a century ago. On the Fourdrinier machine the stock, diluted to between 97½ and 99½ per cent water, is allowed to flow on to a continuous belt of bronze screen of very fine mesh. As this screen, or "wire" as it is called, moves along, the water drains away. A sidewise shaking of the wire lays part of the fibers crosswise of the sheet to give the paper strength in both directions, otherwise it would tear apart easily.

As the water drains out, the pulp forms a wet thin

sheet composed of millions of fibers adhering to each other. A series of felt blankets and rolls remove more of the water. Then the paper travels over and under a long series of huge steam heated cylinders which dry out most of the remaining water. Sprays of sizing materials close the surface pores, then another series of electrically controlled dryer rolls bring the sheet to the desired degree of dryness. The proper finish is given the surface of the paper by "ironing" between steel calender rolls at the end of the paper machine, and the paper is then wound in large rolls. From the machine, the paper is taken to the final process, called "finishing." In the finishing room the rolls are cut into sheets, then inspected and counted. In selecting drawing paper the following things are important: Body (thickness, grade and color); Surface; Erasing Quality. The customary highest quality is usually selected. For detail drawings, which may be subjected to considerable handling, a tinted paper which does not show the effects of soiling may be preferred. In any case the grade or quality of the paper selected should depend upon whether the drawings to be made are to have a

permanent or temporary character. If they are to be kept for record the paper should be made of 100 per cent rag stock. The surfact of the paper to be employed will depend upon whether the drawing is to remain in pencil, or whether it is to be inked or colored. For pencil drawings a paper with a light tooth is generally preferred. Where many fine ink lines are to be drawn, a smooth surface usually gives the best results, especially if the drawings are to be reproduced by photographic processes. Where color work forms thickness of drawing paper is such that unless of very inferior quality, its tearing strength is sufficiently high to readily withstand the handling which it ordinarily receives, either in the drawing room or the shop. Whether it will retain its strength and color as time progresses is a matter which cannot be readily ascertained by the draftsman since a chemical analysis is required, and so,in this respect, he had best rely upon the reputation of the house from which it is purchased. The grade and color of the paper to be selected will depend upon the kind of drawing that is to be made. For fine drawings a clear white paper with a sandgrain or pebbled surface is generally selected. Standards for

drawing paper have been worked out for cutting economically from the rolls as follows: 2/



Standard Drawing Sheets Sizes

A--8½ x 11
B--11 x 17
C--17 x 22
D--22 x 34
E--34 x 44

FIGURE 2

2/ The American Society of Mechanical Engineers
29 West 39th Street, New York, N. Y. ASA-Z14.1--1935

CHAPTER IV

UNIT 4: LETTERING AND NUMBERS

Written language as a means of expression was one of the greatest developments in the history of mankind. Without this means of conveying information, there probably would be no civilization. Before written language, man's communication was through motions of the face, hands, and body.

Aa you know from reading the History of Paper, pictured drawings in crude fashion on rocks or walls were the means of expression giving descriptions of objects older than the written language. From these pictures hieroglyphics were developed as an early form of writing.

The ancient Assyrians, Chaldeans, and Egyptians used stone slabs for many important records.

With these contributions the Phoenician alphabet was developed. This alphabet consisted of 22 letters, from which the Greeks took 15 to make up 24 of their own. The Romans adopted 18 of the Greek letters, added 7 more, and made a modification of other Greek letters. The Anglo-Saxons took all the Roman letters and added u, v, and w.

With the invention of printing by Johann Gutenberg, lettering became an individual expression of the designer, who made his own type. The early lettering style was generally the handwriting of the designer. Many of these styles are in use today, such as Old English, Script, et cetera. In Mechanical Drawing, lettering is one of the most important parts of drawing, explaining the work. If done well it makes everything look good on the drawing; if done poorly, it spoils it all. In the drafting room, vertical or inclined single Gothic is used for general drawing. For Architectural drawing lettering is used which is vertical and ornamental in style. If the inclined letters are used, the slope is known as 2 to 5 which is approximately 67½°. In our lettering sheets, both styles, Vertical and Inclined, are illustrated showing the construction with stroke numbers, so as to make it easy to get correct outline and uniform appearance. This can be learned only by careful, conscientious, and thoughtful practice.

Lettering should be uniform in height. Letters in words should be close together and equally spaced. The spacing of words should be at least equal to the height of the letters. Beginners usually think that it

is beneath their dignity to draw guide lines, but no draftsman would think of lettering without such lines. Guide lines are to be drawn very lightly just so that they can be seen, 1/8 of an inch apart. This applies also when tracing, and do not rely on the guide lines on the drawing beneath. In our lettering we will use only the capital letters, as small letters are not used much in the drawing room of today.

To emphasize any lettering underline it. Lettering is an individual problem and many rules or suggestions could be offered. The truest gage of a neat draftsman is GOOD LETTERING.

CHAPTER V

UNIT 5: MEASUREMENTS

We use the term mile in every day conversation and have a pretty good idea of what that distance is. We hear a radio announcer say that the ball is five inches from the goal line and we can visualize the distance. We think in terms of miles and feet and inches, but how many of us realize the importance of these measurements in every day life and how they came about. Authorities say that early man could count only with his fingers or his toes, or by piling up pebbles. He measured things with his hand or foot. Eventually it was realized that these measurements varied with the size of the man doing the measuring and consequently when several men got together to barter it became necessary to select a measure which all could agree on as a standard, such as the arm's length of the tribal chief or king. For example, in England in the 12th Century the yard was considered as being the distance from the King's nose to the end of his thumb. Consequently when cloth was sold in the market place the buyer and the seller used the measurements of the King to cut the cloth.

Later the yard was established as follows: Three barley corns from the middle of the ear, dry, set end to end made an inch, 12 inches a foot, three feet a yard. Many such standards were selected through the years, but they were all developed in relation to the human body or some other variable and consequently were not constant. The first measure to be developed on a more stable basis was the meter established by scientists in France who based it on the earth's diameter and circumference. The present legal equivalent of a British yard is approximately 0.9143992 of a meter. One foot is 1/3 of a yard and so we come to the 12" rule or scale as it is called that we use in mechanical drawing.

The scale is used primarily to enable us to draw in the right proportions an object that is too large to draw in its actual size or conversely an object that is too small. In other words a scale is used to reduce or increase dimensions. Whenever practicable the object is drawn to full size, i.e. 12" = 1'. If the drawing has to be reduced to half the size then 6" = 1', if to quarter size 3" = 1'. It is sometimes necessary to increase a drawing or double its size so that it can be more easily read. There are three kinds

of scales: The Mechanical, Architect's, and Civil Engineer's. We use a scale that is triangular in shape and has edges showing the division of two of these scales, the mechanical and architect's. These scales differ in units of measurement and in the way these units are subdivided. The mechanical engineer's scale has a unit of one inch which is subdivided into 8ths, 4ths, 12ths, and 16ths. The architect's scale has a unit of one foot which is subdivided into 12ths. The Civil Engineer's scale has the same units as the Mechanical Engineer's, that is one inch but it is divided into multiples of 10. The graduations on the Engineer's scale are as follows:

12" = 1' - 0" Full size 1/4" = 1' - 0" 48th size
6" = 1' - 0" 1/2 size 1/8" = 1' - 0" 96th size

Architect's Scale

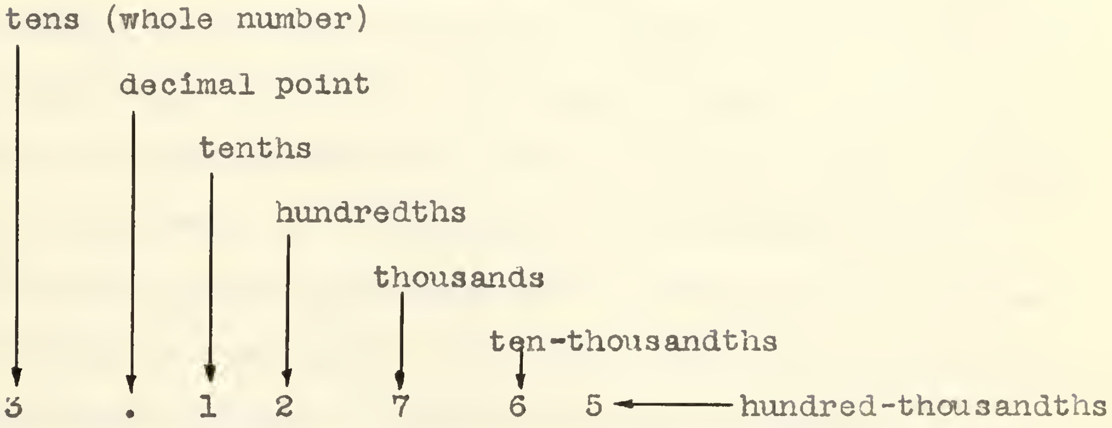
1/2" = 1' - 0" 24th size
12" = 1' - 0" Full Size 3/8" = 1' - 0" 32nd size
3" = 1' - 0" 1/4 size 1/4" = 1' - 0" 48th size
1½" = 1' - 0" 1/8 size 3/16" = 1' - 0" 64th size
1" = 1' - 0" 12th size 1/8" = 1' - 0" 96th size
3/4" = 1' - 0" 16th size 3/32" = 1' - 0" 128th size

Civil Engineer's Scales

1" = 100' - 0" 1" = 40' - 0"
1" = 80' - 0" 1" = 30' - 0"
1" = 60' - 0" 1" = 20' - 0"
1" = 50' - 0" 1" = 10' - 0"

The 12 inches is broken into parts in the form of common fractions by dividing by 2. This is known as the binary system. A drawing can be made in 12 different sizes. The Architect's and Mechanical Engineer's scale is in 10ths of an inch and is used for highways et cetera. When accuracy is needed for a very fine measurement the decimal system is used for the reason that fractions representing a very small part of an inch, for example, 1/342 are too awkward to use. The decimal system permits measurements in 10ths, 1000ths, and 10,000ths. For example, 1/4 of an inch can be expressed as .250 its decimal equivalent. This result is obtained by considering figure 1 as representing an inch, a whole unit, and dividing by 4. In drawing, it frequently becomes necessary to convert fractions to decimals or vice versa. Tables have been worked out to accomplish this purpose quickly. That is to make it unnecessary to do the individual calculations. Decimals can be found in most mechanical handbooks and drawing books. The Metric System of measurement is in use in practically all countries except Great Britain and the U. S. This system has a great many advantages over our own, one of which is the rapidity with which conversions can

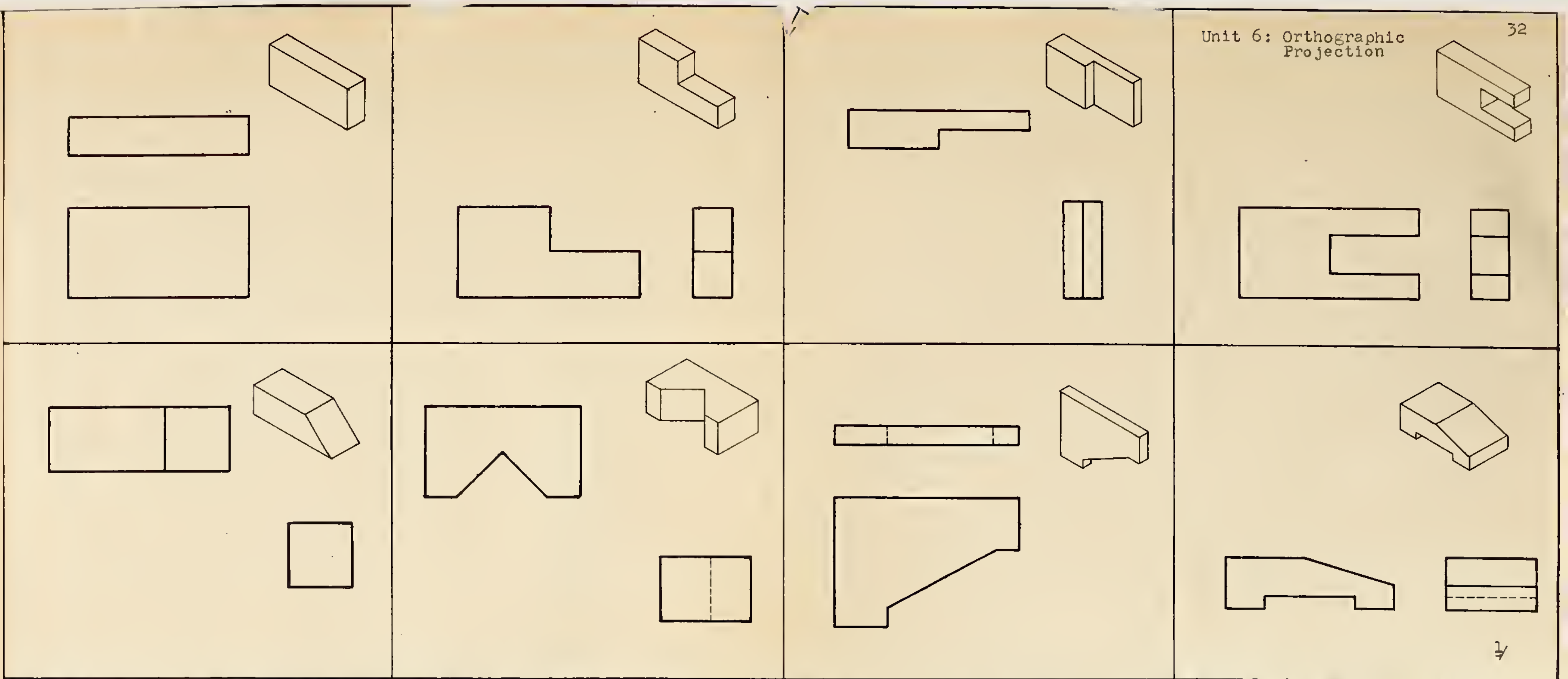
be made from one unit to another. The reason for this is that the Metric System is based on decimals and the basic unit of measure, the meter, can be divided into 100 equal parts called centimeters. This is a decided advantage, inasmuch as fractions can be done away with, and there is no need of converting a measurement from rods to yards, to feet to inches. A conversion to a larger or smaller unit of measurement in the Metric System i. e. kilometer, centimeter, is accomplished simply by moving the decimal point. The U. S. legalized the Metric System in 1926, but this means only that the system may be used, not that it must. Consequently only a few industries have adopted it. Scientists, Engineering Societies, Physicians, Chemists, have advocated its adoption. In using the scale, always start at the zero just after the indentation.


tens (whole number)
decimal point
tenths
hundredths
thousands
ten-thousandths
3 . 1 2 7 6 5
hundred-thousandths

The scale is not used to draw lines with, it is used only to measure the distance wanted. Besides the scale, there are many measuring tools such as outside and inside calipers, micrometers and protractors, for angles and degrees. The protractor sheet, which follows, will explain the measurement of angles. Later, we will scale drawing to a closer tolerance, allowing parts to fit and interchange, such as a bolt going through a hole and a nut fitting the threaded part of the bolt correctly. To set standards, an organization was sponsored by the Society of Mechanical Engineers, known as the American Standards Association. You will work later with drafting room standards that were established by this Association, and a scale reading sheet will be passed out. Today fixed micrometers, combination gages and automatic gaging machines have been developed scientifically, to such an extent that it is now possible to take measurements which are accurate to within 1/10,000th of an inch.

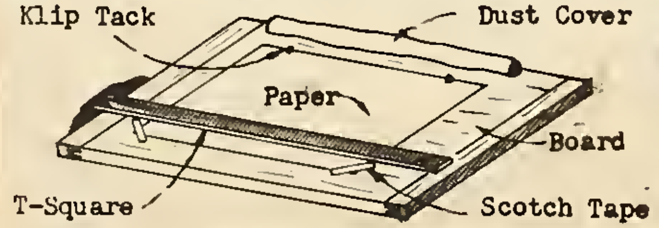
NUMBERS:- From early counting habits, the invention of a counting frame called the Abacus developed and is still used in kindergarten grades. When the total of ten beads have been counted on the right hand, rod one is moved over to the next rod to represent ten; then

beyond that to hundreds and thousands. For centuries no one could think of a way in which numbers, as shown on the Abacus could be written on paper or carved in stone. When the Arabs set up their universities, they taught a way of putting pictures of beads on paper that they had learned from the Hundus. Like all great inventions, this was a great step forward in the use of numbers. It first consisted of a series of numbers from 1-9. Later, the sign of zero was added. This made it possible to change the value of a number such as 1 to 10 or 100. The Greeks used the letters of their alphabet to represent different numbers such as A-1, B-2. The Romans used Roman numerals such as I, II, III, IV. By means of methods of recording mumbers, the Greeks and the Egyptians discovered many scientific facts about lines on a flat surface. Such men as Thales, Pythagoras, and Euclid developed many expressions of mathematical theory which are part of our geometry in drawing today. About 1500 A.D., the principle of Abacus was extended so that fractions of a whole number could be represented. Practically all fractions can be represented by decimals as well as by fraction.



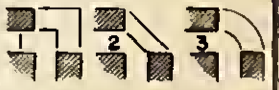
1/

SQUARING PAPER: Place upper left hand corner of paper under left hand clip, square top edge of paper with top edge of T-square. Slip right hand corner of paper under right hand clip. Test for accuracy. In testing and drawing always make sure that the head of T-square is against the working edge of drawing board. With back part of hand smooth left edge of paper and place a piece of scotch tape in lower left hand corner then sweep hand from upper left hand corner to lower right and place a piece of scotch tape in corner. This will keep paper smooth for working surface.

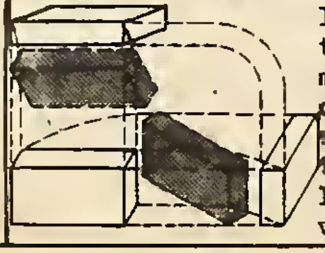


ORTHOGRAPHIC PROJECTION: This term is used to illustrate the views used in mechanical drawing. Orthographic means true shape of object. This word is derived from the Greeks. Projection means the movements of lines describing the object. In this sheet various views will be completed by projection. From this projection sheet the basic principles of drawing will enable you to do more complicated drawings as we advance.

3 WAYS TO PROJECT END VIEW

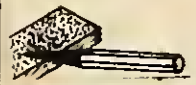


1. 45° with horizontal and vertical lines. 2. 45° lines. 3. Use of compass



1. Select for Front view the one that will give most complete picture of object. 2. Top view should be projected as illustrated. 3. Project lines from Front and Top view to get End view.

PENCILS: Two pencils are generally used in drawing 2H for lettering, figures, sketches, and arrowheads, and 4H for drawing. Letters are stamped on pencil to show the degrees. Always sharpen pencil on unmarked end. To do good work a pencil must be sharpe.



PENCIL POINT: To get extra sharpe point use sandpaper block holding pencil horizontally and turning to keep it uniform.

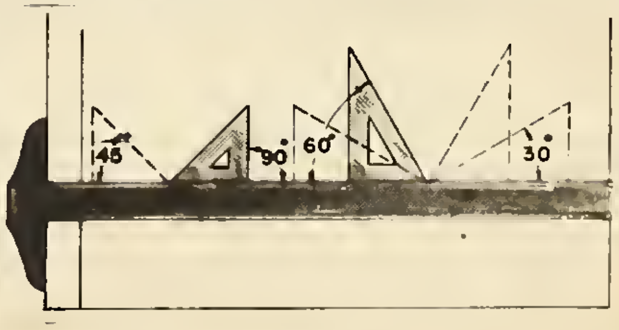
CONVENTIONAL LINES: 3 lines are used in this sheet, Full Line which represents the object. Projection Line which is used to project from one view to another, this line should never touch the drawing and should be drawn light. The Hidden Edge Line represents edges which are not seen, uniform length 1/8 inch with 1/16 inch break between. This line is lighter than the full line.

Full Line
————————

Projection Line
————————

Hidden Edge
— — — — — — — —

TRIANGLES: Triangles are used to draw vertical lines 90°, sloping lines 30°, 60° and 45°. In using triangles always place on top edge of T-square. Draw lines, when possible, on left hand side of angle from bottom up. 24 combinations of the 360° in a circle can be located by the T-square and the 2 angles in various combinations. An angle sheet will follow later showing the various combinations.



1/ French Thomas, Mechanical Drawing. McGraw Hill, N.Y. 1934 p. 167

Figure 3. Orthographic Projection

CHAPTER VII

Unit 7. Chart Sheets [1]

The American Drawing and Drafting Room Standards are sponsored by the Society for the Promotion of Engineering Education and The American Society of Mechanical Engineers, located at 29 West 39th Street, New York, N. Y. These organizations are sponsored by large engineering and manufacturing companies who contribute financial support, whereby periodical questionnaires are sent out for suggestions and improvements in mechanical drawing. A booklet known as Drawing Room Standards is a catalog publication numbered Z14.1-1935, which contains all the latest Drafting Room Standards. The Mechanical Drawing Association of New England through the cooperation of the American Society of Mechanical Engineers, have printed the drawing charts which follow. They are available to drawing teachers, who are members of the Association in order that they may use them in the teaching of standards in the field of drawing.

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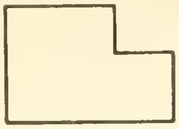
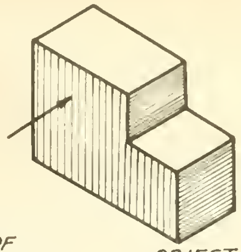
[1] Adapted from Mechanical Drawing Association of New England.

IN MECHANICAL DRAWING AN OBJECT IS DESCRIBED IN TERMS OF ITS FACES. THE DRAWINGS OF THE VARIOUS FACES ARE CALLED VIEWS OR PROJECTIONS.



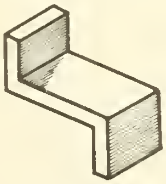
VIEW OR PROJECTION OF FACE INDICATED BY ARROW



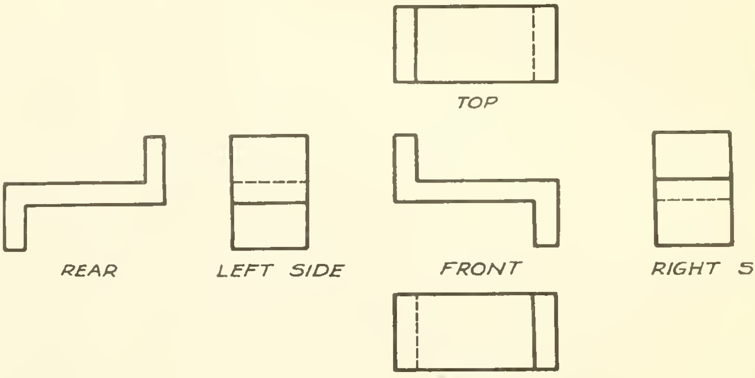
OBJECT

FRONT VIEW: IS THE VIEW SHOWING MOST INFORMATION ABOUT THE OBJECT, NOT NECESSARILY WHAT THE OBJECT LOOKS LIKE FROM THE FRONT. IT IS PREFERABLE TO PLACE THE OBJECT IN ITS NATURAL POSITION. WHERE POSSIBLE THE FRONT VIEW IS THE VIEW OCCUPYING THE MAXIMUM OF AREA.

IN SPACE THERE ARE THREE MUTUALLY PERPENDICULAR PLANES. THE PROJECTIONS OR VIEWS OF THE OBJECT ON THESE PLANES ARE 6 IN NUMBER. THE FRONT VIEW IS USUALLY DRAWN FIRST.



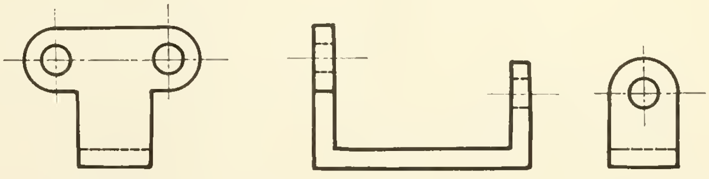
THE SIX VIEWS AND THEIR USUAL LOCATION ARE SHOWN AT THE RIGHT.



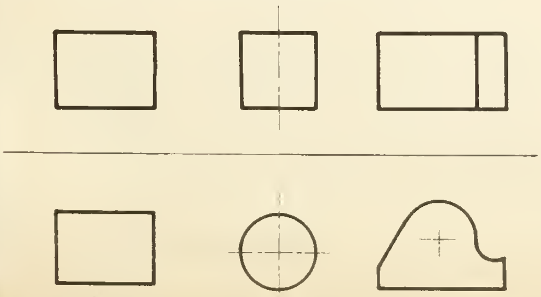
$$\text{WHEN THE} \left\{\begin{array}{l}\text{LEFT AND RIGHT}\\ \text{REAR AND FRONT}\\ \text{TOP AND BOTTOM}\end{array}\right\} \text{VIEWS ARE NEARLY ALIKE, THE} \left\{\begin{array}{l}\text{LEFT}\\ \text{REAR}\\ \text{BOTTOM}\end{array}\right\} \text{VIEWS ARE OMITTED. THE}$$

MAJORITY OF DRAWINGS THEN, WILL HAVE ONLY THE FRONT, TOP, AND RIGHT SIDE VIEWS.

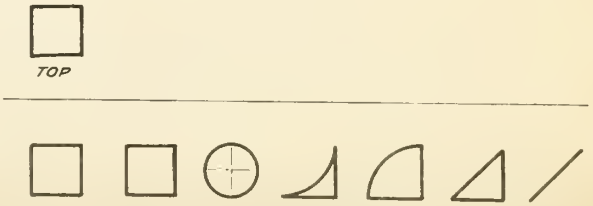
WHEN FOR EXAMPLE, THE RIGHT AND LEFT SIDE VIEWS ARE DIFFERENT, BOTH ARE SHOWN. THEY NEED NOT BE COMPLETE VIEWS, BUT TOGETHER THEY MUST SHOW ALL THE INFORMATION.



IN MAKING VIEWS LINES ARE DRAWN FOR CORNERS AND TANGENTS AS IN (A) (B) (C) BELOW.

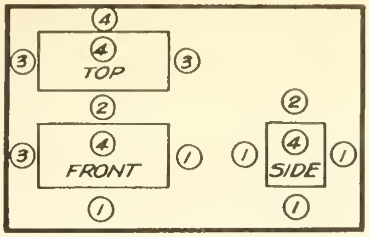


ENOUGH VIEWS OF ANY OBJECT MUST BE MADE TO COMPLETELY DESCRIBE IT. FOR EXAMPLE, THE TOP AND FRONT VIEWS ALONE FOR THE OBJECT SHOWN BELOW WOULD NOT BE ENOUGH.



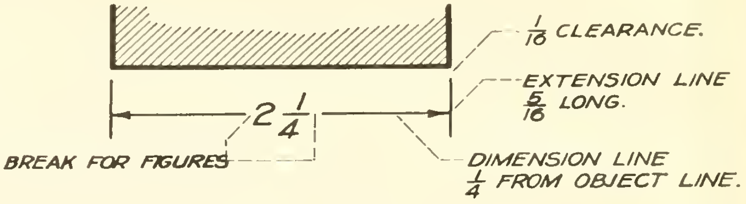
ORTHOGRAPHIC PROJECTION

LOCATING DIMENSIONS:


④
③
④
TOP
③
②
②
③
④
FRONT
①
①
④
SIDE
①
①
①

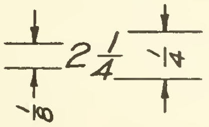
THE NUMBERS IN THE SKETCH AT THE LEFT INDICATE THE ORDER OF PREFERENCE FOR LOCATING DIMENSIONS. HOWEVER, WHERE ANY SPECIAL FEATURE IS CONCERNED, DIMENSIONS SHOULD BE GROUPED NEAR OR IN THE VIEW WHERE THAT FEATURE IS SHOWN MOST CLEARLY.

A TYPICAL DIMENSION:

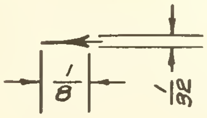

1/16 CLEARANCE.
EXTENSION LINE 5/16 LONG.
2 1/4
BREAK FOR FIGURES
DIMENSION LINE 1/4 FROM OBJECT LINE.

PROPORTIONS OF:

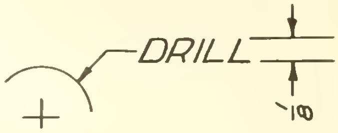
FIGURES:



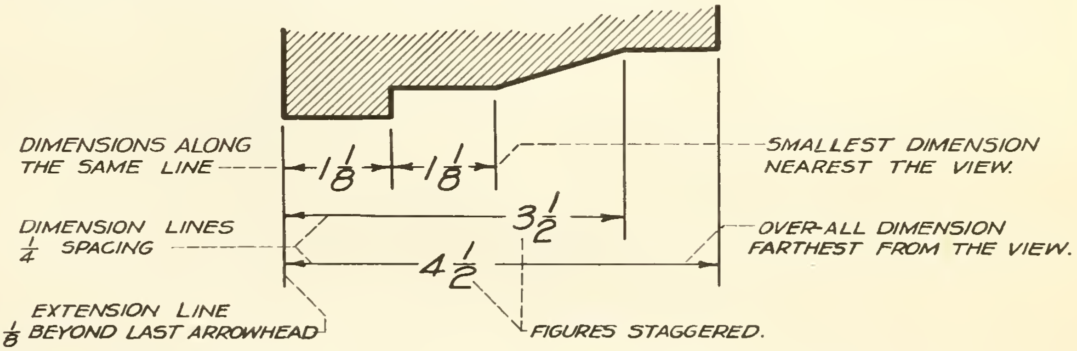
ARROWHEADS:



NOTES:



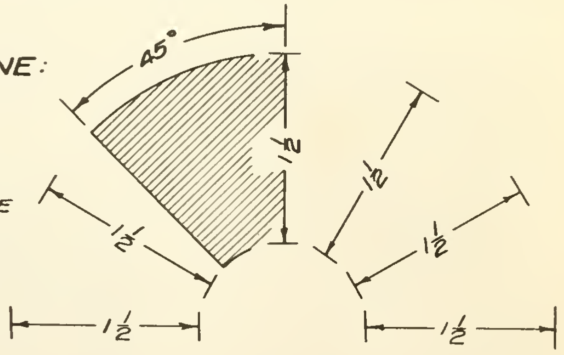
WHERE A GROUP OF DIMENSIONS ARE INVOLVED:


DIMENSIONS ALONG THE SAME LINE
1 1/8
1 1/8
SMALLEST DIMENSION NEAREST THE VIEW.
DIMENSION LINES 1/4 SPACING
3 1/2
OVER-ALL DIMENSION FARTHEST FROM THE VIEW.
4 1/2
EXTENSION LINE 1/8 BEYOND LAST ARROWHEAD
FIGURES STAGGERED.

RELATION OF FIGURE TO DIMENSION LINE:

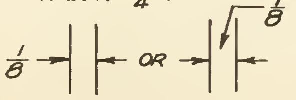
THE DIRECTION FROM WHICH THE NUMERALS ARE READ CHANGES AT THE VERTICAL LINE

THE SHADED AREA SHOULD BE AVOIDED IF POSSIBLE.


45°
1 1/2
1 1/2
1 1/2
1 1/2
1 1/2
1 1/2

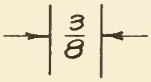
DIMENSIONING IN A LIMITED SPACE:

UNDER $\frac{1}{4}$:



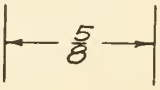
ARROWHEADS AND FIGURES OUT.

FROM $\frac{1}{4}$ TO $\frac{1}{2}$



ARROWHEADS OUT, FIGURES IN.

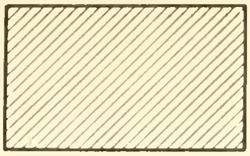
OVER $\frac{1}{2}$

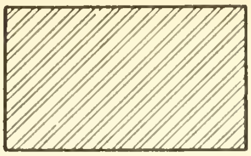


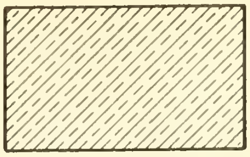
ARROWHEADS AND FIGURES IN.

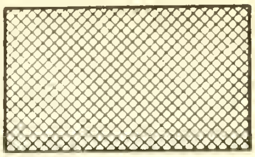
NOTE: WHEN ALL OF THE DIMENSIONS ON A DRAWING ARE IN INCHES, THE SYMBOL (") IS OMITTED.

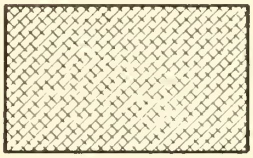
SECTION LINING

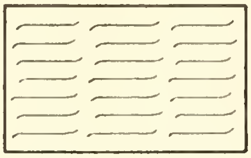

CAST IRON

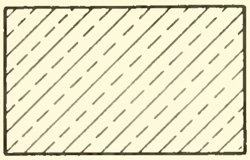

STEEL

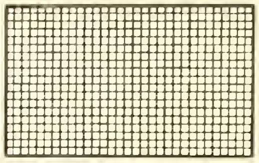

BRONZE, BRASS, COPPER AND COMPOSITIONS

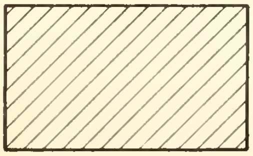

WHITE METAL, ZINC, LEAD, BABBITT AND ALLOYS

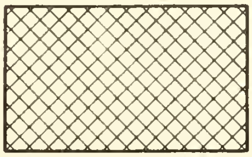

ALUMINUM AND ALUMINUM ALLOYS

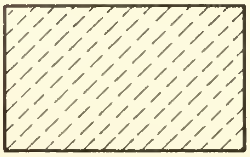

FLEXIBLE MATERIAL, FABRIC, FELT, RUBBER ETC.

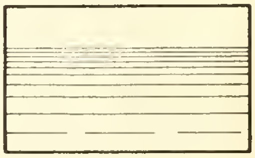

FIRE BRICK AND REFRACTORY MATERIAL

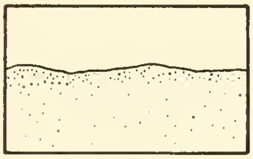

ELECTRIC WINDINGS, ELECTRO MAGNETS, RESISTANCE, ETC.

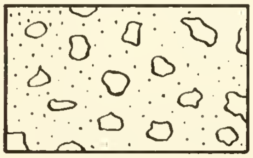

BRICK OR STONE MASONRY

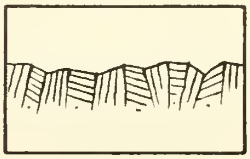

SOUND OR HEAT INSULATION. CORK, HAIR-FELT, WOOL, ASBESTOS, MAGNESIA, PACKING, ETC.

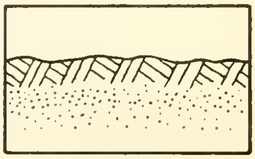

MARBLE, SLATE, GLASS, PORCELAIN, ETC.

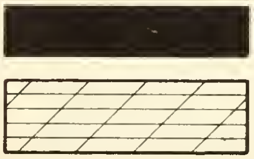

WATER AND OTHER LIQUIDS

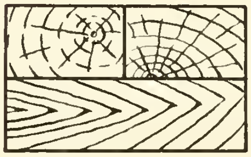

SAND


CONCRETE

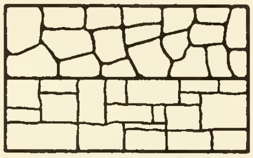

ROCK

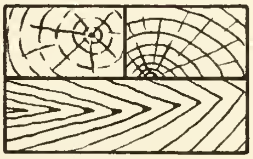

EARTH

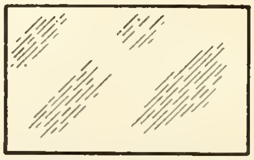

ELECTRIC INSULATION, VULCANITE, FIBRE, MICA, BAKELITE, ETC. SHOW SOLID FOR NARROW SECTIONS

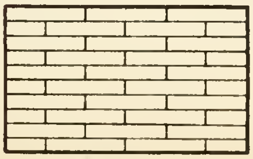


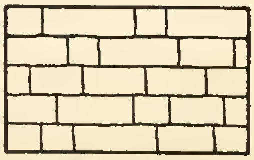
OUTSIDE VIEWS


UNCOURSED AND COURSED RUBBLE


WOOD


TRANSPARENT MATERIAL, GLASS, CELLULOID, ETC.


BRICK

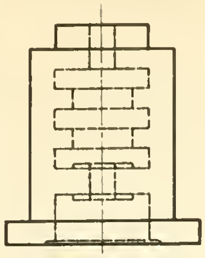

ASHLAR

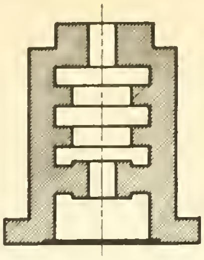
E.H.T.

SYMBOLS

SECTION VIEWS SHOULD BE USED WHEN THE INTERIOR CONSTRUCTION CANNOT BE SHOWN CLEARLY BY OUTSIDE VIEWS.

ADVANTAGE OF SECTION VIEWS.

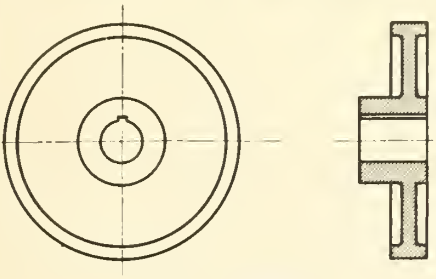

FRONT VIEW

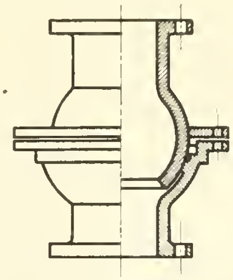

FRONT VIEW-SECTION

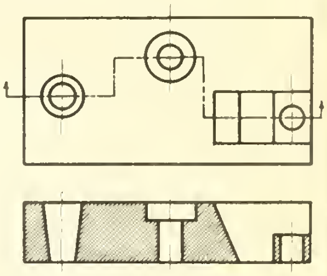
SECTION LINES: 1/32 - 1/8 IN. APART, 45° TO BORDER LINE OF DRAWING.

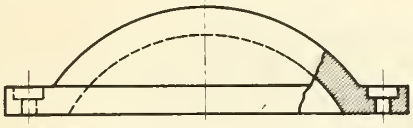
TYPES OF SECTIONS.

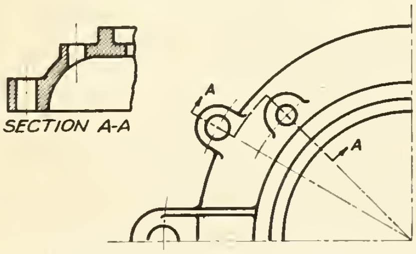
1. FULL SECTION - THE OBJECT IS CUT COMPLETELY ACROSS.
2. HALF SECTION - PARTICULARLY ADAPTED TO CIRCULAR PARTS.
3. BROKEN LINE SECTION - FOR BRINGING INTO ONE PLANE VARIOUS POINTS OF INTEREST.
4. PARTIAL SECTIONS - (A) IN PLACE - (B) REMOVED - } USED TO CLARIFY SOME SPECIAL FEATURE.
5. REVOLVED SECTION - USED FOR SOME SPECIAL FEATURE THUS SAVING AN ADDITIONAL VIEW.
6. PHANTOM SECTION - SHOWS THE RELATIONSHIP BETWEEN MATING PARTS.


1. FULL SECTION.

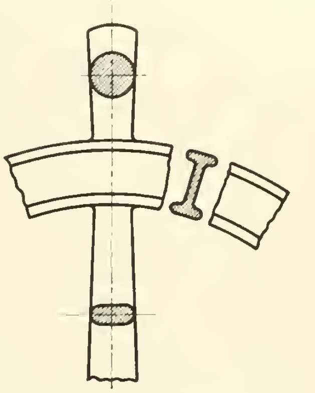

2. HALF SECTION.

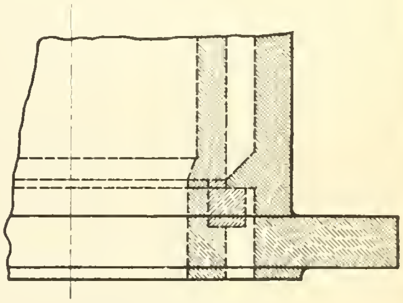

3. BROKEN LINE SECTION.


4(A) PARTIAL SECTION-IN PLACE

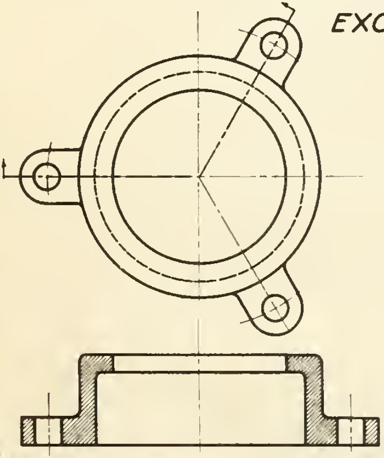


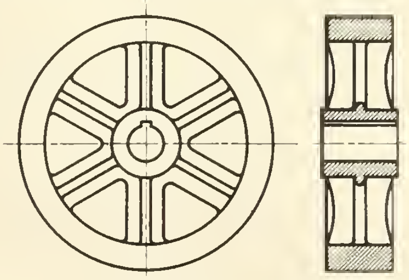
4(B) PARTIAL SECTION-REMOVED

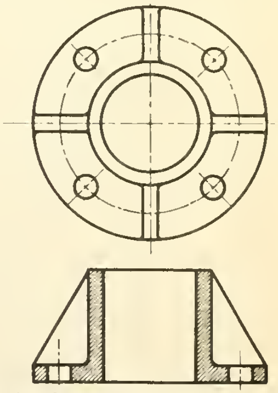

5. REVOLVED SECTIONS.


6. PHANTOM SECTION.

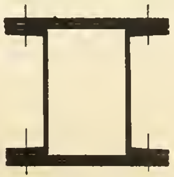
EXCEPTIONS TO ORTHOGRAPHIC THEORY.

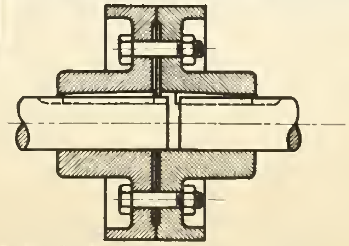

TO AVOID FORESHORTENING, AND TO CLARIFY THE DRAWING, SECTIONS ARE MADE SYMMETRICAL

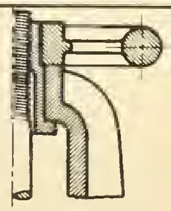

IN THE INTEREST OF CLEARNESS, SECTION LINES ARE OMITTED WHEN THE SECTION PLANE PASSES THROUGH A RIB, WEB, OR SIMILAR PARALLEL ELEMENTS


HOLES ARE BROUGHT INTO THE CUTTING PLANE SHOWING THEIR TRUE DISTANCE FROM CENTER

OTHER EXCEPTIONS.


SECTIONS TOO THIN FOR LINE SECTIONING ARE SHOWN SOLID.

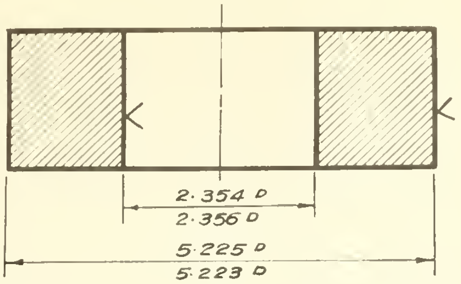

SHAFTS, BOLTS, NUTS, KEYS, ETC., ARE NOT SECTIONED


SECTION LINES CHANGE DIRECTION PASSING BETWEEN ADJACENT PARTS.

WHERE ACCURATE FITS BETWEEN MATING PARTS ARE REQUIRED, IT IS NECESSARY FOR THE DRAFTSMAN TO SPECIFY SIZES SO THAT ALLOWABLE ERROR WHICH MAY EXIST WILL STILL PERMIT A SATISFACTORY FUNCTIONING OF THE PART. IF A SIZE MUST BE HELD TO THREE DECIMAL PLACES, LIMITS SHOULD BE GIVEN.

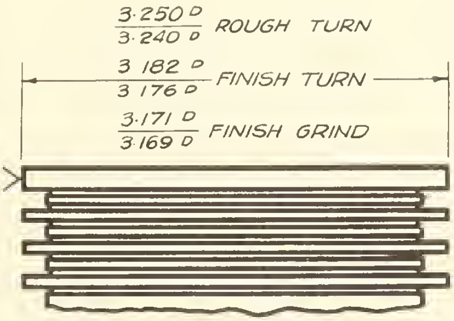
FIRST METHOD:

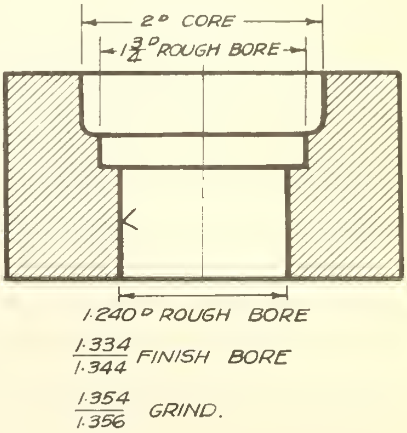
FOR SMALL PARTS WHERE GAGES ARE EXTENSIVELY EMPLOYED.


2·354 D / 2·356 D
5·225 D / 5·223 D

FOR INTERNAL DIMENSIONS THE MINIMUM LIMIT IS PLACED ABOVE THE LINE.

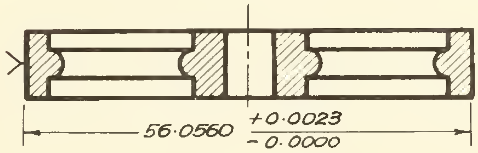
FOR EXTERNAL DIMENSIONS THE MAXIMUM LIMIT IS PLACED ABOVE THE LINE.


3·250 D / 3·240 D ROUGH TURN
3 182 D / 3 176 D FINISH TURN
3·171 D / 3·169 D FINISH GRIND


2D CORE
1¾D ROUGH BORE
1·240 D ROUGH BORE
1·334 / 1·344 FINISH BORE
1·354 / 1·356 GRIND.

SECOND METHOD:

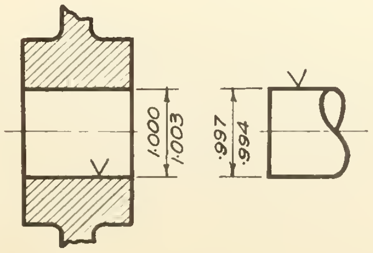
FOR LARGER PARTS AND WHERE FEW GAGES ARE EMPLOYED.


56·0560 +0·0023 / −0·0000

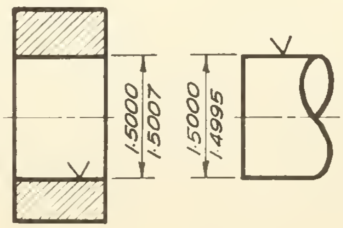
THE CALCULATED SIZE TO THE REQUIRED NUMBER OF DECIMAL PLACES IS GIVEN FIRST, AND IS FOLLOWED BY THE TOLERANCES PLUS AND MINUS, WITH THE PLUS ABOVE THE MINUS.

THE MINIMUM CLEARANCE SPACE BETWEEN MATING PARTS IS CALLED THE ALLOWANCE, AND IS CONTROLLED BY THE DIMENSIONS OF THESE PARTS. THE ALLOWANCE DETERMINES THE LOOSENESS OR FIT OF THE PARTS. EIGHT CLASSES OF FIT ARE RECOGNIZED: 1- LOOSE, 2-FREE, 3-MEDIUM, 4-SNUG, 5-WRINGING, 6-TIGHT, 7-MEDIUM FORCE, 8-HEAVY FORCE AND SHRINK.

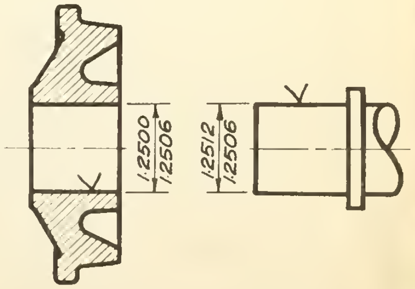
EXAMPLES:


1.000
1.003
.997
.994

LOOSE FIT


1.5000
1.5007
1.5000
1.4995

SNUG FIT


1.2500
1.2506
1.2512
1.2506

MEDIUM FORCE FIT.

LIMIT DIMENSIONS

CHAPTER VIII

Unit 8: DRAWING INSTRUMENTS

There are many styles and types of drafting instruments, some inexpensive, some very costly. Remember however that whatever type is used, abuse and not use is what ruins any drawing instrument. Germany was the first country to make instruments commercially. In Nurmeberg, there is a street named after instrument makers, known as "Compass Makers Lane". In this old city there were organized many guilds, such as the Compass Makers Guild, made up of craftsmen skilled in the making of instruments. These instruments were made individually and with mathematical precision, for those who needed them. All of the work was done by hand and with the finest steels. Most drawing instruments continued to be made in Germany until 1900 because of low cost labor with which the American manufacturers could not compete even with a high tariff. With the usual American ingenuity, manufacturers in the United States developed a mass production method by which excellent instruments with a very high degree of precision are made. Most sets are made of a good quality steel and are chrome plated instead of silver plated as in the German method. Before complete drawing sets, such as we now can buy in

a compact case were made, many of the early craftsmen designed their own instruments for their individual use. Daedalus was probably one of the earliest users of the compass for measuring and describing arcs and circles. Early stone masons and carpenters of ancient times made their tools as they needed them. From one of these craftsmen came the T-square which was used to draw lines, to mark wood to be sawed. The mason made up angles of different sizes and curves. Almost all of these instruments were made of wood and the more elaborate had boned handles with individual carved designs. As the field of drawing expanded many individual craftsmen would make up instruments and go about selling them. From this small individual business has developed one of the largest manufacturing industries, fine precision instruments, one which employs several thousand people.

CHAPTER IX

Unit 9: SKETCHING

The ability to make freehand sketches, orthographic or perspective, is essential to all who are studying drafting. It is one of the easiest ways to learn how to read a drawing and to make details of parts or ideas that have to be drawn in the drafting room. In an engineering office the chief engineer must have skill in making rapid freehand sketches that could be passed on to the drafting room to make a working mechanical drawing. In making a sketch it is not necessary to make it to size, but it should be in good proportion. Sketch paper with cross sections of $\frac{1}{4}$ inch squares are provided to help you in sketching. Below are suggestions that will be helpful to you.

Steps in making a sketch:

1. Draw the center lines of the various views.
2. Block in the necessary views.
3. Draw squares to inclose any circles.
4. Darken the outlines of the views.
5. Put in the extension and dimension lines.
6. Add dimensions, notes, finishes.

Obtaining the measurements:

For these a scale, inside and outside calipers are essential. The procedure is as follows:

1. Note finished surfaces and holes, and use these as reference in taking dimensions.
2. In measuring holes, measure from edge to edge, as it is impossible to accurately estimate location of center.
3. In measuring a distance try to arrange it so that edge of the scale and the edge of the object rest against a common flat surface.
4. In using outside caliper, place end of caliper against end of scale for accuracy.
5. For inside measurements use inside transfer calipers.
6. Average the casting dimensions. If, as in the sketch, the hole is off center and outside is rough, average the casting thickness and use the same center for both circles.
7. Ribs are shown with parallel sides, using thickness dimensions.
8. Use circle area for curves as much as possible. Locate the centers for the area.

9. Accuracy: Rough **casting**dimensions should be accurate to the nearest 1/16". Finished surfaces should be to nearest 1/32 (03125), except where decimal dimensions are needed.
10. Include all notes as to name, number required, material, finish, fillets, assembly notes.
11. Thread can be measured by means of a thread gage, or one can get an imprint of the threads on some soft material, measure and check the result against tables listing the standard sizes.
12. Make fillets and rounds 1/8 radius on small castings, and 1/4 radius or more on large castings.
13. Double check all important dimensions on the castings.

CHAPTER X

UNIT 10: TRIANGLES

The understanding and use of angles is essential to the solution of many drawing problems.

Angles were probably put to very practical use first by the Egyptians in connection with the construction of their pyramids. "One ventilating shaft leading to the royal chamber was so accurately placed that the dead Pharoah was illuminated by the Dog Star when it crossed the meridian.[1]" This is astonishing accuracy! Heights were figured by reckoning the length of a shadow and the angle of the sun above the horizon. Five or six thousand years ago the Egyptians and the Babylonians are said to have discovered a general rule about the sides of a right angled triangle-one which you mathematics students would immediately recognize-the square on the longest side (hypotoneuse) of a right angled triangle is equal to the sum of the squares on the other two sides. The Egyptians and Babylonians both knew that the circumference of a circle always has the same ratio to its diameter. This ratio we call "Pi" 3.1416 (π).

Degrees in a circle are thought to have had their

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[1] Hogben, Lancelot, F.R.S., Mathematics for the Million W. W. Norton & Company, Inc. 1941 N. Y. Page 47

origin in the circular track of the sun worked out in 360 steps by the Babylonians whose year consisted of 360 days. These 360 divisions each representing one night and day were shown on maps showing the stars.

All angles are measured in terms of degrees. Those which do not fall in the group of 24 possible combinations of degrees described previously on sheet one can be measured by an instrument called a protractor. A protractor is a semi-circle with a straight edge in the center of which is the vertex point. On the outer edge of the protractor divisions by degrees are given where angles can be measured. The measurements of a circle are as follows:

60 seconds (") = minute (')
50 minutes = degree (°)
90 degrees = quadrant
4 quadrants = circle = 360°

CHAPTER XI

UNIT 11: PICTORIAL DRAWING

There is an increasing demand for the use of perspective drawing to help convey working drawings more clearly to the worker , and to assist him in getting a better mental picture of the object. Such drawings as machine, assembly or catalogue illustrations, piping layouts, building construction are some of the many used.

The three major classifications are Axonometric, Oblique, and Perspective. It is sometimes difficult to show the shape of an object in two or more views, in such cases it may be represented by a picture or isometric drawing. An isometric drawing has the advantage of showing the three dimensions of an object in such a way that they can be measured with an ordinary scale.

The Isometric Axis which forms the basis of an isometric drawing are drawn as shown in Figure 4. Lines parallel to an isometric axis are known as isometric lines and appear in their true length.

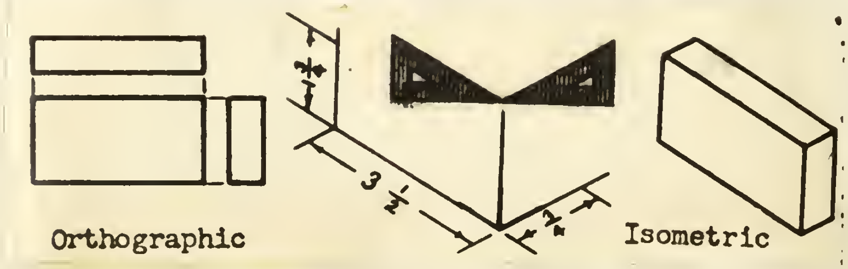

FIGURE 4. Isometric Axis

NON-ISOMETRIC

Any lines in an isometric drawing which are not parallel to an isometric axis are known as non-isometric. These lines do not appear in their true length and are drawn by locating the end points as shown in Figure 5.

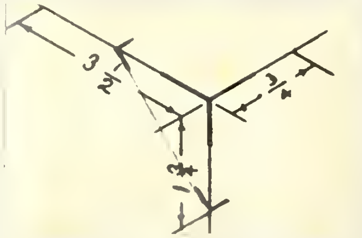

Figure 5. Non-Isometric Axis

Angles between lines on an isometric drawing do not show in their true size and cannot be measured in degrees. In a cube all angles are right angle but when drawn in isometric some would be 60° and others 120°. In drawing angles other than 90° the lines forming them must be transferred from the orthographic views as shown in Figure 6 and complete as Figure 7.

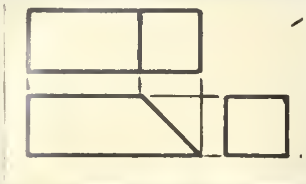

Figure 6

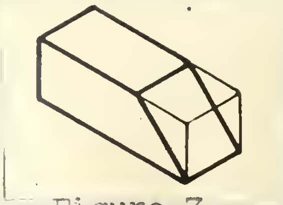

Figure 7

Figure 6. Orthographic views with Figure 7 showing non-isometric lines.

ISOMETRIC CIRCLES

Circles in isometric drawing appear as allipses and are drawn as shown in Figure 8. The important rule to remember is that every circle has its own set of centers.

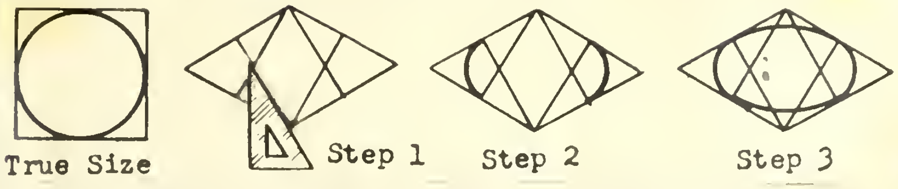
True Size
Step 1
Step 2
Step 3

Figure 8. Steps in Ellipses

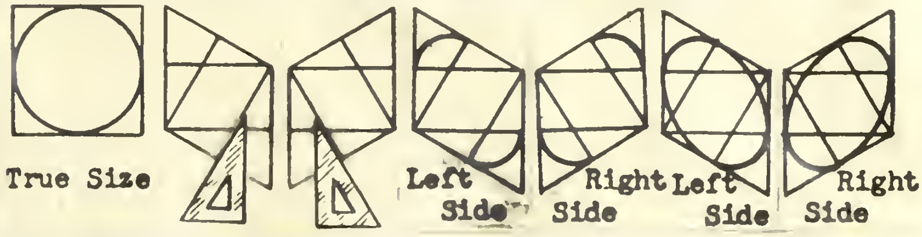
True Size
Left Side
Right Side
Left Side
Right Side

Figure 9. Isometric Circles

Isometric arcs are drawn in the same manner as isometric circles using as much of the construction of Figure 9 as may be necessary. Thus for a quarter circle the construction shown in Figure 10 would be used.

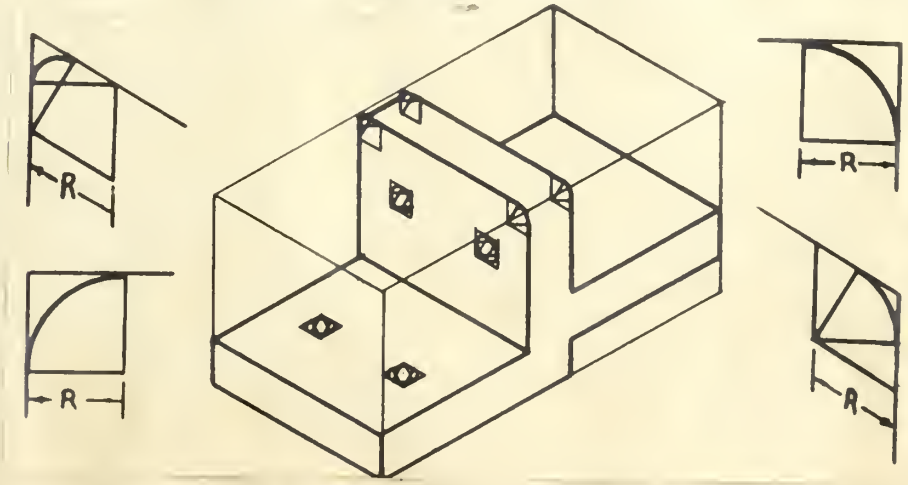

Figure 10. Isometric Quarters

CONSTRUCTING ISOMETRIC CURVES

To make an irregular shape as shown below, use a true front view with cross lines cutting the object, with equal squares. These same lines are drawn in the perspective angle, and are located on the points that are taken from the true shape. After the points are located properly, they are sketched lightly, and then completed with the irregular curves.

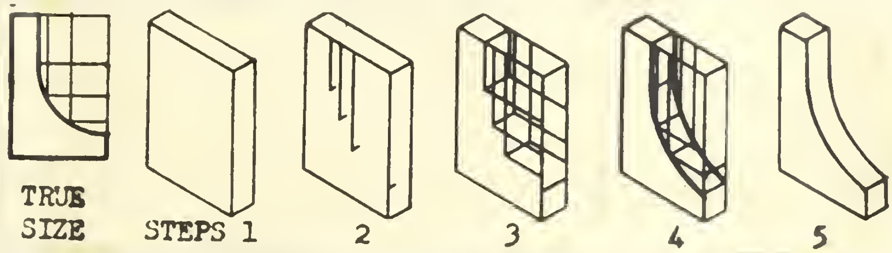

Figure 11. Isometric Irregular Curves

CHAPTER XII

Unit 12: MANUFACTURING

EARLY MANUFACTURING:- It is difficult to think of any product with which we come in contact daily, in the manufacture of which a drawing of some kind has not played an important part. The medieval craftsman was not concerned with tools as we regard them today, primarily because the market for his handiwork was limited, and he was thus rarely called upon to produce more than one of the same article. He would have used tools, lathes, and machine tools if he had had them. The only reason that he made his candlesticks, and pots, by hand was that it was the only possible way for him to produce those articles. The result was that articles which today are within the reach of every person, were in the past, found only in the homes of the wealthy.

Even after such machine tools as lathes, shapers, milling machines, were developed, the production of articles in any appreciable quantities was a process of hand fitting the various parts. It was not until the demand for products increased and this hand fitting had to be eliminated that we had the beginnings of interchangeable manufacture. Thus today, parts

manufactured in different plants, cities, and even countries, can be brought together at the assembly plant, assembled, and made to function satisfactorily. This can be accomplished because the parts are identical within the limits specified by the engineers, having been made by the use of tools and dies.

We should not adopt the idea that mass production methods are to be found only in the large industries such as the automobile, radio, and washing machine, et cetera. One has but to walk thru a ten-cent store to realize that the articles found there could not possibly be sold at those prices unless they were produced in tremendous quantities.

"Interchangeable manufacture is the art of producing complete machinery or mechanisms, the corresponding parts of which are so nearly alike that any part may be fitted into any of the given mechanisms." Interchangeable manufacture is a requisite of mass production, for without it there would be only quality production--merely the production of parts which would not have the necessary dimensional control to make them interchangeable.

The early industrial development in England shows many attempts--none of them particularly successful--

Boston University
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to produce interchangeable parts in quantity. Each attempt had to be written off as a loss due to lack of essential items which we take for granted today; namely, machines, materials, methods, and men. One attempt will be mentioned here in detail, for the reason that it was carried out along lines that are today considered industrially practical.

In 1801, Sir Marc Isambard Brunel developed the drawings for a set of machines to produce blocks for the English Navy. (Here we note one of the first realizations that the machines should be given equal considerations with the parts for the production of mechanisms in quantities. In all previous attempts, the parts had been turned out first, then were handfitted together.) Brunel, not being a mechanic, got John Madsley, the outstanding mechanic of that time, to help him with the constructions of the machines.

Together they built and set-up 44 machines, and arranged them in four classes or departments:-

1. Sawing--both reciprocating and circular--for roughing out the blocks.
2. Boring, mortising, shaping, and "scoring"--for finishing the blocks.

3. Turning and boring the sheaves, riveting the brass liners, and finish facing the sides.
4. Hand forging, turning, and polishing the iron pins.

It is a matter for conjecture as to why early American attempts at interchangeable manufacture and mass production were slightly more successful than the English attempts. Perhaps they took more cognizance of the reasons for English failures, or perhaps it was due to "Yankee ingenuity". However, early American attempts are also records of "trial-and-error" and "cut-and-dry" methods. Eli Whitney in 1789 contracted to deliver 10,000 muskets to the United States Government. It took him eight years to deliver that amount.

The manufacture of clocks gives us a good example of the advances made in development of interchangeable manufacture and mass production in early American industry. We find in the early records the following:-

1807--Eli Terry contracted to produce 4,000 clocks for the United States Government. In 1841, he systematized the work on the movements, and then on the bases of the clocks.

1818--Joseph Ives invented a mantel clock with cast brass wheels. In 1835, he developed an eight day clock

with rolled brass parts.

1838--Chauncy Jerome brought out a cheaper clock with rolled brass parts.

1848--Aaron T. Dennison tried to manufacture watches by machinery, but without success, for the machines were not yet refined enough for such precision work.

By 1855, machine methods and interchangeable manufacture had progressed to such a point that the manufacturers were able to produce 400,000 clocks a year, at a cost of only 50¢ apiece.

After the Civil War, the idea of interchangeable manufacture began to permeate and influence American industry, and it was taken for granted when, in the early 80's and 90's typewriters and bicycles began to be produced. This change was forced upon industry as a result of its feverish and unsuccessful attempts to produce guns in quantity for the Civil War.

In 1902 and 1903, the development of interchangeable manufacture gained impetus by the steady demands made by the automobile industry, and there were additional refinements and improvements in machines, methods, and materials.

To get a vivid impression of the scope of modern manufacturing on a small unit - let's assume that you have invented a chuck and have a good market for its sale.

THE STORY OF THE CHUCK

To protect your invention, the first thing you would do is apply for a patent. Early records show patents were granted in England during the reign of Queen Elizabeth and King James to various guilds, which were exclusive monopolies for patent protection, until monopolies were put to an end in 1623. The earliest patent issued in this country was granted by the General Court of Massachusetts Bay Colony, in October, 1641, to Samuel Winslow for a process of manufacturing salt. The patent laws of the United States were intact in 1790, and the first person to receive his patent rights was Samuel Hopkins of Vermont, July 31, 1790, for a process of making pot and pearl ashes. Many of the early patents were signed by George Washington and Thomas Jefferson before a Commissioner was appointed in 1802.

It would be advisable to engage a registered patent attorney, one who is familiar with the preparation of data and the drawings. Patent drawing is a highly specialized art, and a patent lawyer knows how to bring out the most important parts of the drawing, those must be presented to the patent office. The fee for this kind of work is about $10 per hour. Before the patent drawings

are made, sketches are drawn, showing the idea so that the attorney can arrange for well-trained searchers to make a preliminary patentability search of the pertinent United States patents to determine if your invention is patentable. If the searcher finds that your invention is patentable, drawings are then made upon a medium weight, pure white Bristol board. The size of the sheet is 10 x 15 with an inch margin leaving the "sight" 8 x 13. Within this margin are all the details of the drawing which is drawn in black India ink with your signature, date, and the signature of a witness. Sometimes, it is necessary to have several drawings to give complete information about the invention. The drawing is arranged to show the three views; front, top, and side, with numerals corresponding with working, three view drawings. A written description of the invention telling how it works and its advantages must be attached to the drawing. After all the material has been prepared, it is sent to the Patent Office Examiner in charge of the particular class of inventions to which your idea relates, who makes an extensive search to learn whether your invention is new. If the Examiner finds that you are entitled to the invention, it is then filed and

granted to you. Sometimes it takes from one to two years before the patent is granted. However, in the meantime you can manufacture your invention stamped "Patent Pending".

There are four types of patents. The first of these is "Mechanical Patent," such applies to the Chuck. The term "Mechanical Patent" is used to indicate a patent for an improved article, machine, apparatus or device. This patent is granted for a period up to 17 years. Beyond that it has to be approved by an act of Congress. The first Government Filing Fee is $30, which must be paid when the application is filed; and the Final Fee of $30 may be paid any time within 6 months after the application is allowed. "Process of Method Patent" includes new and useful processes or methods for producing a product. The product may be old, but the process or method must be new to be patentable. If both the process and the product are new, each may be protected by a patent. The term of a "Process or Method Patent" is also 17 years. All Filing Fees are the same for the four type patents. The next group of patents cover new chemical compounds, such as toothpaste and foods. Many proprietary preparations are protected by the registered Trademarks, such as the name Quaker Oats or the Copyright for a book title or song.

"Design Patent" protects you in ownership of a design just as a Mechanical Patent protects you in the ownership of a device. These patents are issued either for 3½ years, 7 years, or 14 years. Government fees are: 3½ years, $10.00: 7 years, $15.00, or 14 years, $30.00. This gives you an idea of how you can protect an invention but in addition there are other opportunities for handling it, such as selling outright to a company or selling on a royalty basis.

Before actual manufacturing starts, several preliminary steps must be taken in various departments of the plant such as blueprint preparation.

Below, is a layout of a modern drafting office with its personnel. It is the duty of the organization as

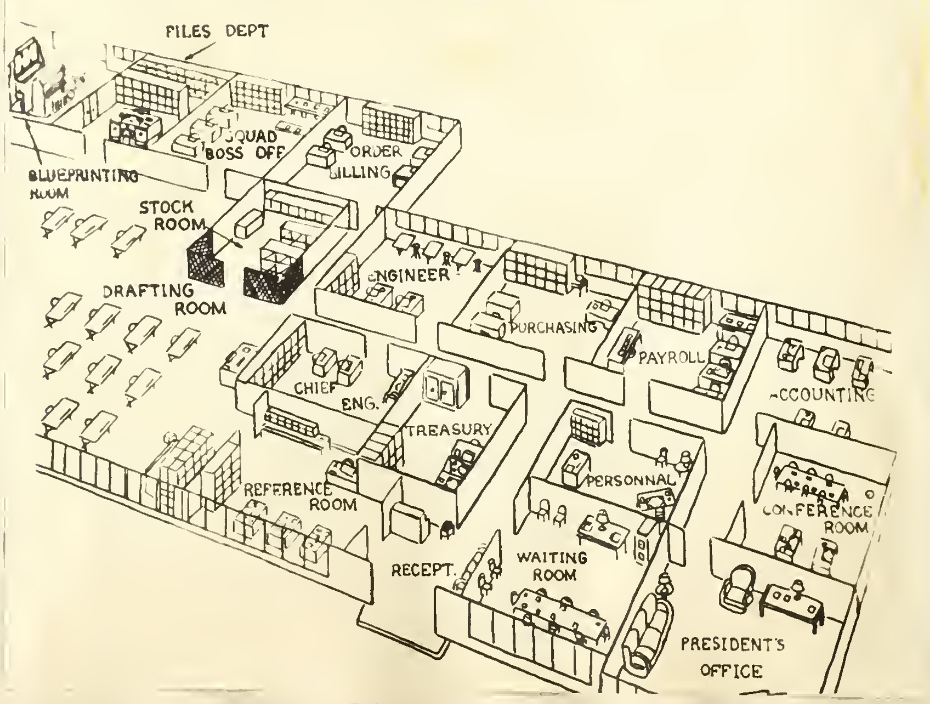
FILES DEPT
SQUAD BOSS OFF
ORDER BILLING
BLUEPRINTING ROOM
STOCK ROOM
DRAFTING ROOM
ENGINEER
PURCHASING
PAYROLL
ACCOUNTING
CHIEF ENG.
TREASURY
PERSONNAL
CONFERENCE ROOM
REFERENCE ROOM
RECEPT.
WAITING ROOM
PRESIDENT'S OFFICE

Figure 12. Drafting Office

illustrated, to supervise the travel of the blueprints thru the various manufacturing steps as shown from the development of the drawings to the finished product. As the slogan goes, "First of all, the Draftsman is every Industry."

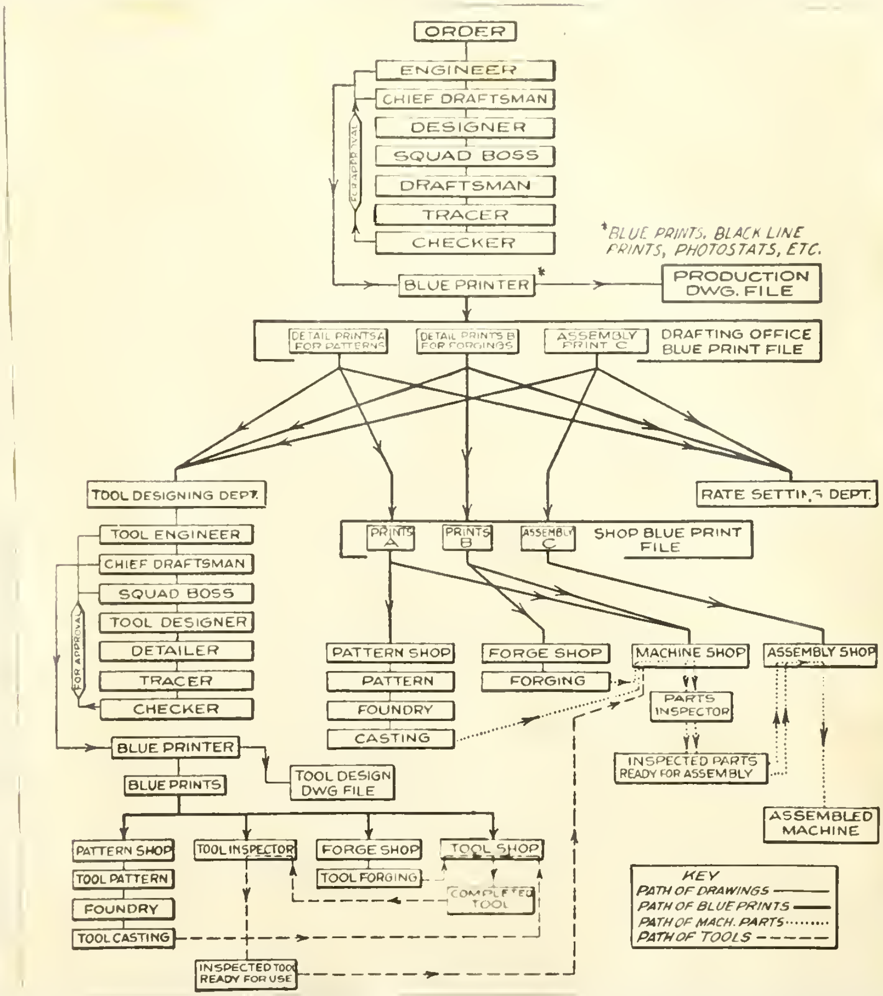
ORDER
ENGINEER
CHIEF DRAFTSMAN
DESIGNER
SQUAD BOSS
DRAFTSMAN
TRACER
CHECKER
FOR APPROVAL
*BLUE PRINTS, BLACK LINE PRINTS, PHOTOSTATS, ETC.
BLUE PRINTER*
PRODUCTION DWG. FILE
DETAIL PRINTS A FOR PATTERNS
DETAIL PRINTS B FOR FORGINGS
ASSEMBLY PRINT C
DRAFTING OFFICE BLUE PRINT FILE
TOOL DESIGNING DEPT.
RATE SETTING DEPT.
PRINTS A
PRINTS B
ASSEMBLY C
SHOP BLUE PRINT FILE
TOOL ENGINEER
CHIEF DRAFTSMAN
SQUAD BOSS
TOOL DESIGNER
DETAILER
TRACER
CHECKER
FOR APPROVAL
BLUE PRINTER
BLUE PRINTS
TOOL DESIGN DWG FILE
PATTERN SHOP
PATTERN
FOUNDRY
CASTING
FORGE SHOP
FORGING
MACHINE SHOP
PARTS INSPECTOR
INSPECTED PARTS READY FOR ASSEMBLY
ASSEMBLY SHOP
ASSEMBLED MACHINE
PATTERN SHOP
TOOL PATTERN
FOUNDRY
TOOL CASTING
TOOL INSPECTOR
INSPECTED TOOL READY FOR USE
FORGE SHOP
TOOL FORGING
TOOL SHOP
COMPLETED TOOL
KEY
PATH OF DRAWINGS
PATH OF BLUE PRINTS
PATH OF MACH. PARTS
PATH OF TOOLS

Figure 13

Travel of a Blueprint

13/ French Thomas, Engineering Drawing. McGraw Hill Book Company, N. Y. 1941, p 168

ENGINEER'S DUTIES.— It is the responsibility of the engineer to supply the draftsman with a readable sketch of the Chuck to be made. This sketch must supply the draftsman with all the information in the form of dimensions and views that he will need in order to make a working drawing.

DRAFTSMAN'S DUTIES.— It is the duty of the draftsman to make a workable instrument drawing of the engineer's sketch. This drawing must be accurately dimensioned and completely noted, in order that the other tradesmen may use these dimensions and notes in making this Chuck.

PATTERN MAKER'S DUTIES.— It has been stated that the engineer must first make an original sketch and then the draftsman must convert this into a readable working drawing. This drawing is then given to the patternmaker who reads the drawing carefully and makes an exact wood model of the object from the dimensions. To do this, he must first make an accurate layout of the drawing on a flat wooden board called a layout board.

The dimensions of this layout are exactly the same as the dimensions of the drawing. However, the pattern-maker knows from foundry experience that the casting after it has been poured, will shrink. All metals shrink when cool and expand when they are heated,

therefore, instead of using a regular rule in transferring the dimensions from the drawing to the layout board, he uses what is known as a shrink rule.

A shrink ruler is graduated the same as a regular ruler, but every foot of it is either 1/16, 1/8, or 1/4 of an inch larger than a regular rule. Shrinkages for metal are as follows:

Cast iron--1/8"
Malleable iron--1/8"
Zinc--5/16"
Brass--3/16"
Lead --5/16"
Copper--3/16"
Aluminum--1/4"
Steel--1/4"

After this layout has been made with the shrink rule the pattern-maker must draw again from his foundry and machine experience to make several other alterations in this layout. First, he must add excess material to the casting to enable the machinist to machine the allowance on the layout for "finish" allowances. Later we will take up the drafting room standards for finishing symbols. Second, the pattern-maker must select well dried, seasoned, pattern-making wood. The most common woods used are clear white pine, mahogany, cherry, redwood, or maple. Now that the pattern has been planned well in advance, the pattern-maker goes about his work cutting the excess wood on various wood-working machines and tools, adding draft to the vertical surfaces to make

them slightly slanted enabling the pattern to be taken from the molding sand, which is usually one-eighth of an inch per foot, finishing it to the exact size very carefully, rounding off outside and inside corners with fillits that increase the strength of the casting and so prevent crystallization of the metal and its pulling apart when cooling off. All surfaces are finished glass-smooth before applying the standard color for finish, adopted by the American Foundrymen's Association, as follows: [2]

1--Surfaces to be left unfinished are to be painted Black.

2--Surfaces to be machined are to be painted Red.

3--Seats of and for Loose Pieces are to be Red Stripes on a Yellow Background.

4--Core Prints and Seats for Loose Core Prints are to be painted Yellow.

5--Stop-offs are to be indicated by Diagonal Black Stripes on a Yellow Base.

DIE-CASTING.--Another form of casting used in molten metal is introduced under pressure, the process is called die-casting. Zinc, tin, and aluminum base alloys are the metals most commonly used because they pour at a temperature which does not destroy the die. Brass may be die-cast, but iron and steel only with

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[2] American Foundrymen's Association: Construction Metal Handbook. American Foundrymen's Association, Chicago, Illinois, 1944, p. 12

alloys. Zinc, tin and aluminum alloys may be cast with a plus-or-minus tolerance of .0005 in. if necessary, and can easily maintain a limit of .0002 to .0003. Holes are usually cored, inserts of other metals being used. A die is expensive to make but economical in the long run for machine operations are greatly reduced. The making of dies is a specialized industry, for a good die-maker must know all the engineering requirements of the manufacturer.

FOUNDRY MAN'S DUTIES.– It is the duty of the foundry man to prepare a mold from the pattern that will make the shape of the Chuck in sand. In preparing this pattern the molder uses a box, called a "flask", which is open at the top and bottom. It is made in two sections, the lower of which is called the "drag" and the upper, the "cope". These are fitted with guide pins to permit accurate realignment of the two sections. The first step required in making a mold from a split pattern, is to lay face down one half of the pattern on the molding board of the "drag" around it. The sand must be "tempered" or dampened to a proper consistency. If it retains its shape, showing all finger marks when squeezed in the hand, it is right. If it crumbles, it is too dry and if it leaves moisture on the hand, it is too wet. Sand

that is too dry will crumble in the mold, while, if the sand is too wet, steam will be formed causing blowholes in the casting. A specially mixed sand, known as "facing" is sifted in against the pattern and patted into place by hand to a depth of one or two inches. "Backing sand" is then used to fill up the "drag" being well rammed in the box to the top and struck off level with a straight edge. The "drag" is then turned right side up on the bottom board and the surface is sprinkled with a parting material to prevent sticking of the "drag" and "cope" on the parting line. The second half of the pattern is set in place in the dowel pin holes of the pattern and the cope is set on top of the drag, with the spruce pin placed to form a pouring hole and filled with sand the same as the drag. The "cope" is then lifted off at the parting and the moulder cuts a gate directly below the spruce hole in the "drag" so that the moulded metal will flow in and not spoil the mold of the pattern. To get the pattern out, the mold is "rapped". To get the imbedded pattern halves out, a short screw is driven into the joint face of the pattern and it is lifted out carefully. Here is where draft in the direction of the center halves of the pattern will be larger so as not to break the edges of the sand mold.

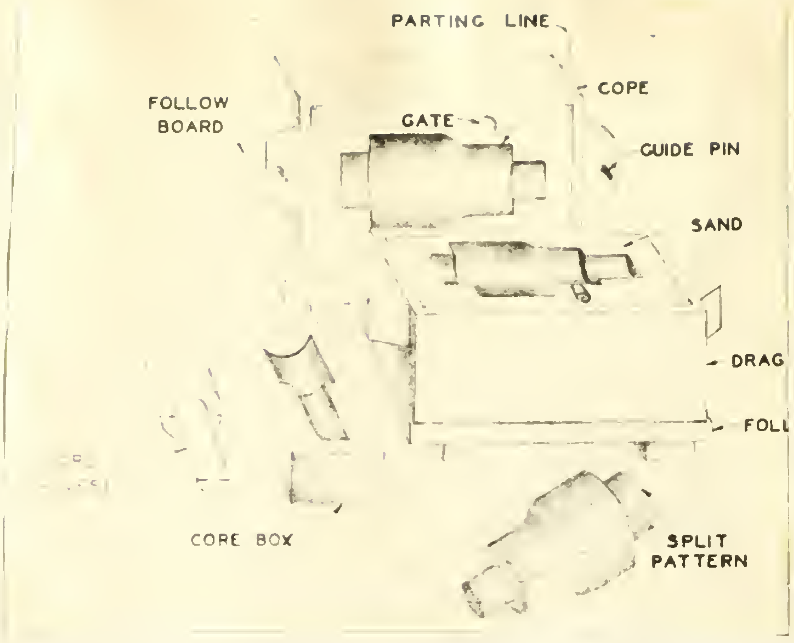
PARTING LINE
FOLLOW BOARD
COPE
GATE
GUIDE PIN
SAND
DRAG
FOLL
CORE BOX
SPLIT PATTERN

FIGURE 14-PATTERN-CORE BOX AND FLASK

To produce the hole in the Chuck a core is made with special sand bonded with linseed oil which hardens when the mixture is baked. In this case the core box only makes half of the core at a time, then the two halves are pasted together to make the form of the full core. (As illustration Figure Fifteen) The core is placed in the drag and the cope is put in place over the drag. The final step is to make a few vent holes in the cope so as to let the gases escape and the mold is ready to receive the molten metal. After the metal has been poured and allowed to cool, the flask is removed from the sand, and the sand is broken away from the mold. A mold and core are used only once.

MACHINIST'S DUTIES: It is the responsibility of the machinist to make this casting into the finished Chuck. When the casting comes from the foundry, it has a great deal of excess metal which must be removed by machining before the casting is a finished product. This metal consists of the spruce into which the metal was poured, draft, a hard outer scale and finish allowances, which were added by the pattern-maker in performing his job correctly.

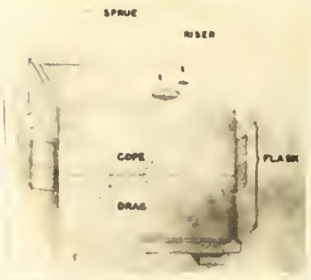

FIGURE 15-PATTERN-DRAG AND COPE ASSEMBLE

If you will look at the drawing just as the machinist must examine the drawing for dimensions and notes, you will notice thirteen main machine operations which must be completed before the Chuck is accurately machined.

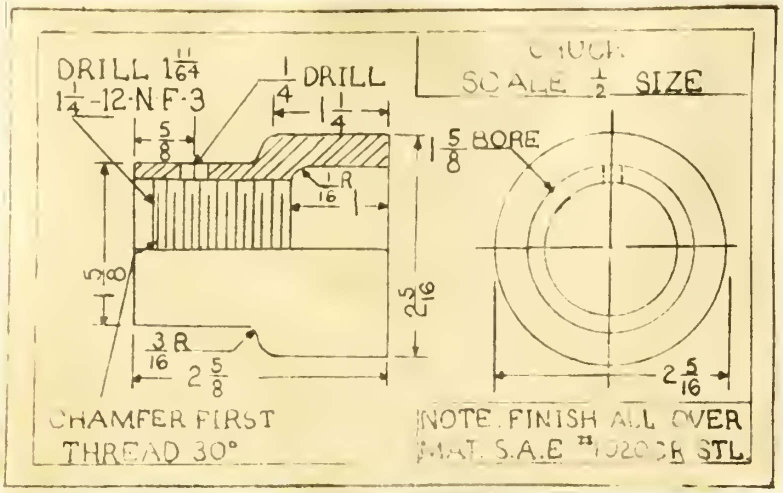
DRILL $1\frac{11}{64}$
$1\frac{1}{4}$-12-N F-3
$\frac{1}{4}$ DRILL
$1\frac{1}{4}$
$\frac{5}{8}$
$1\frac{5}{8}$ BORE
$\frac{1}{16}$R
1
$\frac{5}{8}$
$2\frac{5}{16}$
$\frac{3}{16}$R
$2\frac{5}{8}$
$2\frac{5}{16}$
CHUCK
SCALE $\frac{1}{2}$ SIZE
CHAMFER FIRST THREAD 30°
NOTE. FINISH ALL OVER
MAT. S.A.E #1020 CR STL.

FIGURE 16 - CHUCK DRAWING

These operations are:

1. Chuck small end & true
2. Face end
3. Turn large O. D.
4. Spot center
5. Drill lead hole
6. Bore (both dia.)
7. Tap
8. Chuck other side and true
9. Turn small O. D. and radius
10. Face to length
11. Relieve tread
12. Burr
13. Drill $\frac{1}{4}$ hole thru

From this description of the manufacture of the Chuck it is hoped that you have gained an appreciation of the many various skilled trade, and the cooperative efforts which have made our American system of industrial enterprise possible.

CHAPTER XIII

UNIT 13: METALLURGY

While the extraction of iron from the ore did not originate in Egypt, some of the earliest records of smelting are contained in Egyptian tombs. In the metal furnaces used before 1500 B.C. only a very small amount of metal could be melted. As man learned more about how to use iron he built better furnaces for extracting it from the ore. Iron ore is a compound of iron and other elements usually mixed with impurities. The object of the blast furnace is to remove the oxygen, dispense with the earthy matter, and set free the iron. The blast furnace is constructed very much on the principle of the old fashion base-burner stove. Each furnace requires extensive accessory equipment, together with its complement of "stoves" to supply the hot blast.

To produce pig iron, three ingredients are necessary-iron ore, coke, and lime-stone. These are charged through the top of the Blast Furnace. The lime-stone acts as a flux and slags the earthy matter from the ore. Coke furnishes carbon to relieve the ore of its oxygen and supplies the heat for the metallurgical reactions.

A hot air blast is forced in near the bottom of the furnace. The gaseous products are piped from the furnace top, and are burned to obtain heat and power. As the ore is smelted, the iron and slag trickle down to the furnace bottom, where the slag floats upon the iron and is drawn off. As the iron settles to the bottom, it absorbs silicon, phosphorus, and manganese from the ore; and sulphur and carbon from the coke. The blast furnace is operated continuously, and is tapped at intervals--the molten iron being drawn from the bottom. The iron may be immediately sent to a steel furnace for refining, or may be cast into short sections, or pigs, for future utilization. In this crude state, the product is known as "pig iron".

Steel is the most valuable form of iron. It is an alloy of iron and carbon but it may also have other materials in small quantities and still be classified as steel. The Bessemer Converter was the first successful commercial process for burning carbon out of pig iron and was devised by Henry Bessemer in 1835. In 1863 Sir William Siemens developed a new type of furnace which was first used by Martin, In France. This method is

called the Siemens-Martin Open Hearth process. At the present time more steel is made by this method than by any other. In these furnaces the steel is frequently alloyed for particular uses--for example, with nickel and chromium for increased strength; with vanadium for toughness; with carbon for hardness; with copper to render the products more rust-resisting; and with various other metals for specific reasons.

The past thirty years have seen the rise of the Electric Furnace in steelmaking. This process produces steel of an extremely high quality because the elements and conditions necessary are always under control. The electric furnace consists of an outer shell made with a refractory lining that may be either asset or basic. The bottom is saucer shaped. Heat for the steel making process comes from an electric arc inside the furnace. The electrodes to form this arc, which are of either carbon or graphite, project through the roof. The whole furnace is mounted in such a way that it can be tipped to pour out the molten steel.

When a heat is to be made, a layer of limestone is placed on the furnace bottom. A small amount of either common rust or scale from the rolling mill is also put

into the mixture. The larger pieces of scrap steel are then placed, followed by the smaller pieces. Charging is usually done by hand. The process of charging and melting down unheated metal is called "cold melting". When molten steel is taken from an open hearth furnace and is put into the electric furnace to be further refined the process is called "hot melting".

The scrap steel that is used is carefully selected for quality. Then, the "melter", the man in charge of the furnace, adds the necessary amounts of the elements needed to get the steel he wants.

There are two main periods in the making of steel by the basic electric process; oxidation and deoxidation.

In the oxidation period the charge is melted down and the slag formed after which tests are taken. The sample is analyzed and reported to the melter. If the metal is ready, the slag is drawn off and the metal begins the second step, deoxidation. It is in this period that carbon is added if needed. If an alloy steel is being made the proper amounts of the alloy elements are added. Slag forms and is drawn off a second time. The molten steel is then tapped into a ladle, from which it is poured into molds.

After the refined steel is taken from the furnace it is poured into large upright ingot molds. As soon as the outside of the ingot becomes sufficiently "set", the molds are stripped off.

ROLLING STEEL.- The most important process after the steel has left the furnace is rolling. A rolling mill works the steel ingot something like a rolling-pin works pie crust. The hot steel billet is pressed between two rotating rolls and is elongated by the pressure between them. When special shapes are needed, special rolling mills are used. The rolls are made in the shape which it is desired to produce. The hot steel must pass through the rollers many times, for each pass through the rolls forms the steel a little nearer to the size and shape of the finished product. Most of the finished parts are treated before they are sold. Various parts need different treatments, depending upon the use to which the steel is to be put.

CHAPTER XIV

Unit 14: HEAT TREATMENT

Heat Treatment is an important step in the processing of articles made from metals.

In order to properly heat-treat any tool or other article made of steel, it is absolutely necessary to know exactly why it is that each step is taken and what the result is. The factors are the kind of steel, the temperature to which it should be heated, the length of time it must be held at this temperature, and the method of cooling. No successful treatment is possible without knowing the kind of steel being used and applying intelligently and carefully the basic methods.

In general, steels may be divided into two classes: straight carbon steels and alloy steels. Most carbon steels are hardened in water but some alloy steels must be quenched or hardened in oil and the hardening temperatures of alloy steels may be very different from those suitable for carbon steels.

Straight carbon steels consist of an alloy of iron and carbon with traces of other elements. The carbon content varies from .1- percent carbon to 1.7 per cent.

The carbon content is the controlling element in the hardness, ductility, and tensile strength of the steel, and in the determination of its hardening temperatures.

Alloy steels also contain enough of some other element to exert a marked influence on the mechanical properties and also on the procedure for heat-treating. Tensile strength is the resistance to rupture by pulling, and is stated in pounds per square inch.

Ductility is the ability of a material to be deformed without rupture; drawn into wire, rolled into sheets or forged.

Hardness is resistance to indentation or abrasion. All these properties may be varied by heat-treatment.

Steels are designated by several code systems, the commonest of which is the S.A.E. code (The Society of Automotive Engineers) which has set up a numeral index system for the specification of steels.

For example: S.A.E. #2315 Steel

The first number indicates type of alloy as follows--

1--Carbon
2--Nickel
3--Nickel-Chromium
4--Molybdenum
5--Chromium
6--Chrome-Vanadium
7--Tungsten
8--Silico-Manganese

The second number, (and in cases of a five numeral steel, the second and third numbers), indicates the average percentage of the alloy. (3% Nickel in the example). In the case of a carbon steel the second number has no significance.

The last two numbers indicate the average percentage of carbon in POINTS.--tenths of one percent. (The example contains, .15% or 15 "points" of carbon).

An X before the code number indicates a special case in which there is a departure from the standard and indicates usually a small addition of some element.

The term cold rolled now has no special significance though it usually designates a cold finished 1020 S.A.E. steel. The best way to order stock is by the S.A.E. number and the process of finishing.

It is possible to identify many common steels and cast irons by spark tests on a grinding wheel. Carbon steels will give bursting stars, tool steel will give many white sparks, and cast iron, many short, red zigzag sparks. High speed steel will give short, dull

red sparks and wrought iron, light yellow sparks. [1]

SPARK TESTS FOR HARDENING.

1. Wrought Iron
2. Mild Steel
3. Tool Steel
4. High-Carbon Steel
5. High-Speed Steel
6. Manganese Iron or Steel
7. Mushett Steel
8. Magnet Steel

Cold Rolled Steel (C.R.S.)--S.A.E. #1020 Steel is to be used in every possible case where there is a minimum amount of machining on a detail. (This point should be kept in mind at all times in the design, and stock sizes should be layed-in wherever possible).

Machine Steel (M.S.)--S.A.E. #1020 H.R. Steel--to be used for details that require sizes that do not conform to stock sizes, that require excessive machining, and that require heat treatment.

Tool Steel (T.S.)--to be used for those details that do cutting and are subject to wearing the impact such as cutting tools, punches, die buttons, and gages. The definite type of tool steel to be specified for any detail will depend upon the specific use of the detail. The steel manufacturers' catalogs and also the design room standard books are excellent references for this information.

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[1] American Machinists' Handbook, McGraw-Hill Book Company, N. Y. 1940 p. 1051

High Speed Steel (H.S.S.)--For tool bits, special drills, and reamers.

Aluminum, Wood, and many other materials are used in many instances in the design of certain jigs and fixtures. However, any material other than steel should not be used or specified unless so directed in the tooling instructions.

FINISHING.-Castings are sometimes left in their rough state when smoothness is not particularly required. But working parts in contact with other working parts usually have to be smooth. They may be smoothed by grinding, machine finishing, buffing or polishing. In a drawing, the edge view of a surface to be finished, is marked with an "F".

Other symbols or notes denote other such treatments. It is proposed to eliminate all of these, and mark all such surfaces with a "V", the code number of the degree of smoothness desired being indicated between the open ends of the "V" as example with lines drawn at 60°.

CHAPTER XV

Unit 15: HISTORY OF SCREW THREADS

SCREW THREADS.– The screw thread is one of the earliest mechanical inventions of man, and undoubtedly one of the most fundamental. The Egyptians invented a water screw to raise water from wells for the irrigation of their fields. The principle of the screw was later applied in the invention of the screw press for squeezing grapes and olives.

Leonardo da Vinci, celebrated engineer of the 16th century, made many sketches of machines using screw threads, and was himself the inventor of the square or butress thread.

But for many centuries, every craftsman who made a screw used the particular tooth form and lead that happened to appeal to him at the moment. The screws he made were not particularly accurate--all that was required was that they do the work they were built to do.

It was not until 1841 that any attempt was made to standardize the variety of screw thread designs in existence. The Whitworth system, devised by Sir. Joseph Whitworth, was rapidly accepted by manufacturers of the day, and it looked for a time as though it would become

the single universal standard. However, the International Standard, the United States Standard, and other systems shortly came into existence and were accepted by certain groups or nationalities.

Rngland continues to use the Whitworth thread system and also another similar form known as British Association Thread Series on screws less than one fourth of an inch in diameter.

France used the French and International thread, which in thread form is identical to the U. S. Standard thread. However, all dimensions are given in terms of centimeters instead of inches, so that even though the threads are similar they are not interchangeable.

The Loewenherz thread is still another thread form, developed in Germany for use in fine instruments and chronometers. This series is based on the metric system and is used extensively in Germany. Its principal point of deviation from the International and the U.S.Standard form is in the included angle, which is 53 degrees, 8 minutes instead of 60 degrees.

In the United States a special committee appointed by the Franklin Institute investigated screw thread standards, and on the basis of their studies the William Sellers thread system was accepted in 1868 by the U. S.

Navy. It was known as the Sellers, Franklin Institute, and later as the United States Standard thread.

While this thread system was satisfactory as far as it went, it did not extend below one fourth of an inch in diameter, and so between the years 1868 and 1928 three distinct thread systems were developed to supplement the United States Standard system. These were known as the S.A.E. (Society of Automotive Engineers), the A.S.M.E. (American Society of Mechanical Engineers), and the U.S.S. (United States Standard) thread series. All of these systems used the 60-degrees included angle of the U.S.S. thread, but differed in the range of pitch diameters, pitch, and thread depth.

In 1928, the National Screw Thread Commission changed the name of the U.S. Standard to the "American National Form of Thread," and incorporated in the standard thread system for this country the A.S.M.E., the S.A.E., and the U.S.S. systems.

The present thread series identifications for United States were established as follows:

National 8, 12, and 16 pitch

N--American National 8, 12, and 16 pitch thread

NF--American National Fine

NC--American National Coarse

NA--American National Acme Thread
NPT--American National Taper Pipe Thread
NPS--American National Straight Pipe Thread
NH--American National Hose Coupling Thread
NS--American National Form Thread Special Pitch

APPLICATION OF STANDARD SCREW THREAD SERIES.- The following thread series are quoted from the "Report of National Screw Thread Commission."

The American National coarse-thread series is recommended for general use in engineering work, in machine construction where conditions are favorable to the use of bolts, screws, and other threaded components where quick and easy assembly of the parts is desired, and for all work where conditions do not require the use of fine-pitch threads.

American National fine-thread series is recommended for general use in Automotive and aircraft work, for use where the design requires both strength and reduction in weight, and where special conditions require a fine thread.

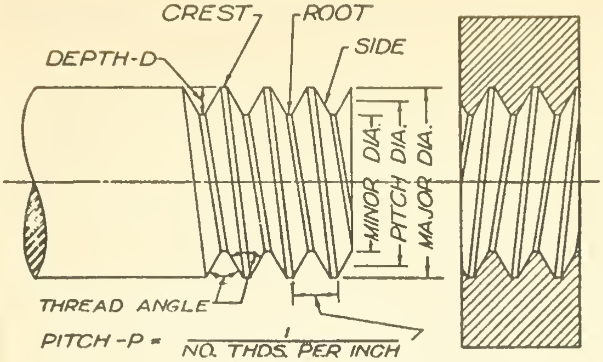
American National 8-Pitch Thread Series -Bolts for high-pressure pipe flanges, cylinder-head studs, and similar fastenings against pressure require that an

initial tension be set up in the fastening by elastic deformation of the fastening and the components held together, such that the joint will not open up when steam or other pressure is applied. To secure a proper initial tension, it is not practicable that the pitch should increase with the diameter of the thread, as the torque required to assemble the fastening would be excessive. Accordingly, for such purposes the 8-pitch thread has come into general use.

American National 12-Pitch Thread Series - Sizes of 12 pitch threads from one-half inch to and including one and three-fourths inches are used in boiler practice, which requires that worn stud holes be retapped with a tap of the next larger size.

The 12-pitch threads are also widely used in machine construction, as for thin nuts on shafts and sleeves. From the standpoints of good design and simplification of practice, it is desirable to maintain shoulder diameters to one-eighth-inch steps. The 12-pitch is the coarsest in general use, which will permit a threaded collar which screws on to a threaded shoulder to slip over a shaft, the difference in diameter between shoulder and shaft being one-eighth inch.

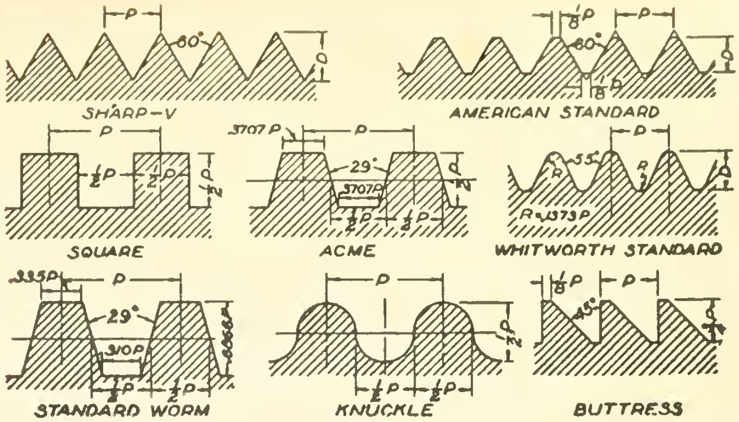
NOMENCLATURE


CREST
ROOT
SIDE
DEPTH-D
MINOR DIA.
PITCH DIA.
MAJOR DIA.
THREAD ANGLE

PITCH-P = $\frac{1}{\text{NO. THDS. PER INCH}}$

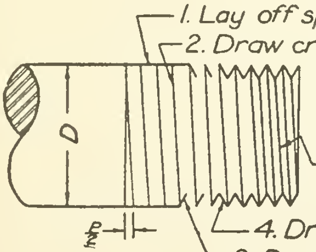
LEAD= DISTANCE NUT ADVANCES ALONG AXIS IN ONE REV.

THREAD FORMS


P
60°
D
SHARP-V
1/8 P
P
60°
D
1/8 P
AMERICAN STANDARD
P
1/2 P
1/2 P
D
1/2 P
SQUARE
.3707 P
P
29°
.3707P
D
1/2 P
1/2 P
ACME
P
55°
R
R
D
R=.1373 P
WHITWORTH STANDARD
.335P
P
29°
.310P
.6866P
1/2 P
1/2 P
STANDARD WORM
P
D
1/2 P
1/2 P
KNUCKLE
1/8 P
P
45°
D
BUTTRESS

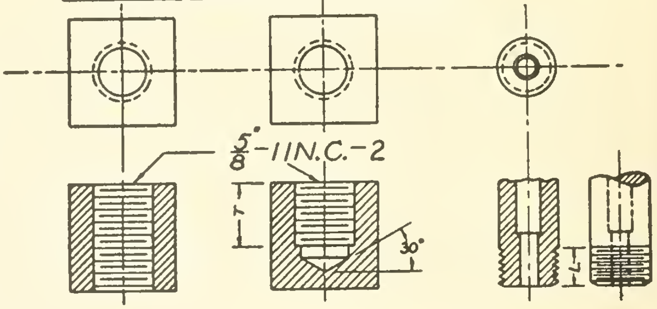
THREAD REPRESENTATION

Steps in drawing V and American (National) Threads, when diameter is one inch or over.

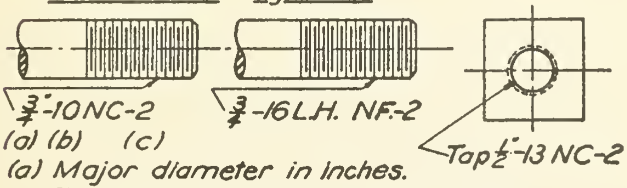


1. Lay off spaces for pitch.
2. Draw crest lines at proper slope— for single lead slope = $\frac{P}{2}$ for double lead slope = P
3. Draw side of thread.
4. Draw other side of thread.
5. Draw root lines.

Threads less than 1" diameter


5/8"-11N.C.-2
T
30°
T

Identification Symbols.


3/4"-10NC-2
3/4-16L.H. NF-2
(a) (b) (c)
Tap 1/2"-13 NC-2

(a) Major diameter in inches.
(b) Threads per inch. L.H.-Left Hand
NC- National Coarse (U.S.S.)
NF- National Fine (S.A.E.)-E.F.-Extra Fine
(c) Class of Fit between bolt and nut.

Screw-thread Fits. (Consult A.S.A. B1.1)

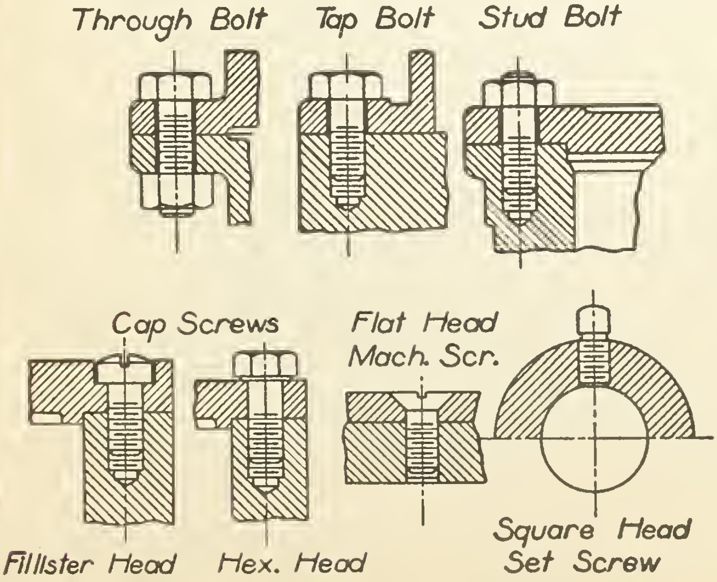
Class 1 Fit.- Used for rapid assembly, where shake or play is not objectionable.

Class 2 Fit.- Recommended for the great bulk of interchangeable screw thread work.

Class 3 Fit.- High quality work, recommended only in cases where high cost of production is warranted.

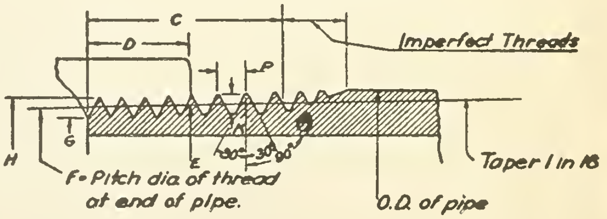
Class 4 Fit.- Intended for unusual requirements more exacting than Class 3. It is not, as yet, produced commercially.

APPLICATION OF BOLTS AND SCREWS



Through Bolt
Tap Bolt
Stud Bolt
Cap Screws
Fillister Head
Hex. Head
Flat Head Mach. Scr.
Square Head Set Screw

PIPE THREAD


C
D
P
Imperfect Threads
G
H
E
30°
30°
90°
Taper 1 in 16

F= Pitch dia. of thread at end of pipe.

O.D. of pipe

C= Length of Effective Thread.
D=Normal Engagement by Hand.
E=Pitch Diameter at Gaging Notch.
G=Root Dia. at small end of Thread.
H=Outside Dia. at small end of Thread.
K=Depth of Thread.

The pipe thread has been standardized by the A.S.A. It is similar to the American National thread in form, but is cut on a conical surface. The crest and root are truncated an amount equal to 0.033 P.

CHAPTER XVI

Unit 16: HISTORY OF INK

Ink has a long and honorable history. It dates back to the ancient times of China, nearly three hundred years before Christ. Many ancient papyrus documents and records written in ink have been found in that country. The chemical change or oxidation upon which the iron gallotannate ink depends for its permanence does not stop with the original oxidation of the ink but is said to continue indefinitely until the ink has faded to pale brown or yellow. This may account for the fact that the ink appearing on old manuscripts in the British Museum is of a rich brown color.

The most important raw material, a gallo-tannic acid, may still be obtained from the gall nuts to be found on the oak trees of Asia Minor as the most important ancient iron mines were located in the country of the Hittites, adjacent to Syria. The union of the tannic acid and the iron produces a colorless liquid which oxidizes to a brownish black. To this colorless liquid black dye is added to make it a practical and attractive drawing fluid.

Ink comes in two forms. The stick, a dry form,

commonly called Indian or Chinese stick ink, is made from lampblack mixed with gelatin or agar-agar and fried in stick form in molds. To prepare for use this stick ink is rubbed on an unglazed porcelain block with water. The ink is ground off in fine particles, which remain suspended in the water. This form is used mostly by architects in making wash drawings, where delicate shading is desired. The liquid India ink which is commonly used is practically the same as the stick ink. It is merely a very fine grade of lampblack held suspended in a liquid which has fairly quick drying properties. This form of ink is much thicker and more opaque than ordinary ink. Due to the thickness and drying qualities, it does not soak into the paper as much as the thinner writing inks.

HINTS FOR INKING.–

1. Draw all lines of the same width with one setting of the pen to insure uniform width of the line throughout the drawing.
2. When several lines radiate from a point, the lines should be drawn from the point, not toward it, allowing each line to dry before drawing the next one in order to prevent a blot which is very

likely to be made at the point.

3. Since it is easier to make a straight line meet a curve than otherwise, do the compass work first, then the straight lines.
4. Be sure that the ink is dry before starting to erase. Bear on the eraser very lightly so as to protect the surface for re-inking. Have a blotter handy in case of a blot.
5. Always strive to be neat, clean, accurate, and keep covered that portion of the drawing which is not being worked on at that time.

ORDER OF INKING.- Before attempting to ink any of the lines, find the centers of all arce, and locate all points of tangency (in pencil). When inking on tracing cloth use powder sparingly; cover all of the surface, and wipe off excess with a clean cloth. Have a pen wiper handy.

ERASING INK.-In erasing ink lines from a drawing or tracing sheet, make sure that the ink is dry before starting. Slip a triangle under the paper to give a harder surface. Use an erasing shield and bear on the eraser very lightly so as not to injure the surface of

the paper or cloth. Rub a little powder on the part erased before starting to re-ink. Have a blotter handy in case of a blot.

USE OF RULING PEN.- The Ruling Pen is used for inking all lines other than circular. The nibs of the pen should have oval shaped points, as in example. Ink is placed between the nibs by the special ink bottle holder from which the pen may be filled with one hand and time saved. Touch the quill between the nibs taking care that no ink is deposited on the outside.

The pen should be held with the adjusting screw away from the T square or angle, the handle resting against the first finger, and the thumb and the second finger in such a position as to be used in training the adjusting screw. In ruling lines the pen should be held in a nearly verticle position against the straight edge with the points parallel to the edge, and the handle inclined slightly to the right. The pen is thus guided by the straight edge bearing just enough against the edge to guide its direction. The line is drawn with a free arm movement, the hand resting on the tips of the third and fourth fingers and keeping the angle of inclination of the pen constant. The line is finished

with the finger movement and not on the free arm motion as described. Just as the end of the line is reached, the pen should be lifted quickly by straightening the first and second fingers.

CHAPTER XVII

Unit 17. BLUEPRINTS

Whenever a number of copies of a drawing are required during a production process, Blueprinting makes them available at one time. For example, we referred in an early lesson, to the drawing that would have to be prepared before production on our Chuck could be started.

A number of people in the plant would have to have a copy of this drawing to carry out their part in its production. The preparation of the individual drawings would be laborious and time-consuming. The same purpose is accomplished by a process known as Blueprinting. A complete tracing is made of the drawing either in pencil or ink. The tracing and a blueprint paper are fed through an endless traveling band that carries it around a half circle plate glass where the exposure is taken and then returned ready to be washed. The printing speed time depends upon the character of work to be reproduced. Operating speed ranges from 2 inches to 2 feet per minute and is controlled by a speed regulator.

Blueprint paper is treated with two chemicals, potassium ferricyanide and ammonium citrate of iron, which in a solution and away from light, do not act

on each other. If the paper is painted with a mixture of the two solutions, dried in the dark, and then exposed to the light, we find, after immersing the paper in water, that an insoluble blue compound has been formed which adheres firmly to it. At any place where the light has not been able to reach the coating on the paper, the chemicals will be unaffected, and will wash off, leaving the paper a clear white.

When we place a tracing between the blueprint and the source of light, the dark lines keep the light from affecting the chemicals. Therefore, when the blueprint paper is washed, we have white lines (where unaffected chemicals have been washed away) on a blue background. If the exposure to the light has been too long and the lines of the drawing have turned slightly blue in consequence, the prints are immersed in a weak solution of potassium bichromate. This tends to make the lines whiter and the background a darker blue, through an oxidizing process.

PART II

LESSON ANALYSIS CHART

In the Lesson Analysis chart which follows, there is a schedule of lessons which covers the technical presentation of the subject of mechanical drawing over a period of thirty-six weeks.

This chart shows how each lesson covers, not only the special task under discussion, but the operation skills that apply to it. At the bottom of the chart is listed topics of related drawing knowledge in the order in which they would be presented.

For example: Lesson one is listed on the chart opposite figure one; the subject of the lesson "Placing the Paper on the Board" is listed under the title "Jobs". The operation skills which make use of the technique learned in lesson one are indicated by a cross reference to this lesson, that is, skills 7, 8, 9, 13, 14, et cetera, all make use of the knowledge learned in lesson one. This lesson includes a short talk on the "History of Drawing".

The order of the lessons as shown on the chart is as follows:

1. Placing Unit Paper on Board
2. Square Paper
3. Sharpen Pencils
4. Layout Sheet

5. Lettering
6. Blocks
7. Cast Iron Dovetail
8. Vertical Holding Block
9. Horizontal Guide
10. Splice Plate
11. Stuffing Gland
12. Pipe Elbow
13. 4 Arm Pulley
14. Shaft Hanger
15. Rocker Arm
16. Fork Wrench
17. Hand Wheel
18. Crane Hook
19. Bolt
20. C Clamp
21. Jack Screw
22. Machine Clamp
23. Turnbuckle
24. Pillow Block
25. Monkey Wrench
26. S Wrench
27. Stillson Wrench
28. Engine Crank

29. Five Arm Pulley
30. Inside Calipers
31. Swing Check Valve
32. Steam Radiator Valve
33. Details Gate Valve
34. Stuffing Box
35. Drill Chuck
36. Spur Gear

THIRTY SIX WEEK MECHANICAL DRAWING COURSE

JOB ANALYSIS CHART

OPERATING SKILLS

	JOBS	1 USE DRAWING BOARD	2 USE T SQUARE	3 USING PENCIL MARK OF DEGREE	4 MEASUREMENT WITH DRAFTSMANS SCALE	5 ERASING	6 MANIPULATING TRIANGLES	7 DRAWING HORIZONTAL VERTICAL, AND ANGULAR LINES	8 DRAWING SMALL CIRCLES WITH BOW PENCIL COMPASS	9 DRAWING ARC WITH LARGE COMPASS	10 USING DIVIDERS	11 MAKING TANGENT CURVES	12 USING CALIPPERS TO GET DIMENSIONS	13 MAKING SECTIONS STUDY OF MATERIALS	14 USING LARGE COMPASS	15 ISOMETRIC	16 PROTRACTOR	17 USE HANDBOOKS	18 USE CATALOGS	19 MEASURING THREADS METHOD OF NOTATION	20 INDICATING ASSEMBLING PROCEDURE	21 MEASURING WITH MICROMETER	22 INDICATING MACHINERY METHOD	23 IRREGULAR CURVES	24 INDICATING MACHINE TOOLS	25 ARRANGING FOR FITTINGS	26 USING NOTATIONS FOR LEFT THREAD	27 DETAILING	28 INDICATING ROUND BREAKS	29 HALF SECTION VIEW	30 INDICATING OF TYPES MATERIAL TREATMENT	31 AUXILIARY VIEWS	32 ACME THREADS	33 QUARTER SECTION	34 INDICATING BRASS MATERIALS	35 CONVENTIONAL THREADS	36 DESIGNING GEAR BLANKS
1	PLACING PAPER ON BOARD	1A						1	1	1				1	1					1	1			1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	SQUARE PAPER	1	2B		2		2	2													2		2	2	2		2	2	2	2	2	2	2	2	2	2	2
3	SHARPEN PENCILS			3C				3	3	3	3	3		3	3					3	3			3			3	3	3	3	3	3	3	3	3	3	3
4	LAY OUT SHEET	1	2	3	4D	5	6	7																													
5	LETTERING	1	2	3	4	5^{E}	6	7																													
6	BLOCKS	1	2	3	4	5	6^{F}	7G	8H	9^{I}_{L}																											
7	CAST IRON DOVETAIL	1	2	3	4	5	6	7	8	9^{J}																											
8	VERTICAL HOLDING BLOCK	1	2	3	4	5	6	7	8	9^{L}_{M}																											
9	HORIZONTAL GUIDE	1	2	3	4	5	6	7	8	9N					14°	15^{P}																					
10	SPLICE PLATE	1	2	3	4	5	6	7	8	9																											
11	STUFFING GLAND	1	2	3	4	5	6	7	8	9	10	11	12	13	14																						
12	PIPE ELBOW	1	2	3	4	5	6	7	8	9	10	11			14																						
13	4 ARM PULLEY	1	2	3	4	5	6	7	8	9	10			13	14		16^{Q}																				
14	SHAFT HANGER	1	2	3	4	5	6	7	8	9	10	11	12	13			16^{R}		18																		
15	ROCKER ARM	1	2	3	4	5	6	7	8	9	10	11	12	13																							
16	FORK WRENCH	1	2	3	4	5	6	7	8	9	10	11	12	13			16																				
17	HAND WHEEL	1	2	3	4	5	6	7	8	9	10	11	12	13			16																				
18	CRANE HOOK	1	2	3	4	5	6	7	8	9	10	11	12	13																							
19	BOLT	1	2	3	4	5	6	7	8	9	10	11	12	13					18	19^{S}	20^{T}	21^{U}	22^{V}	23	24	25	26	27	28								
20	C CLAMP	1	2	3	4	5	6	7	8	9	10	11	12	13		15		17	18	19							26	27	28								
21	JACK SCREW	1	2	3	4	5	6	7	8	9	10	11	12	13	14		16	17	18^{U}		20		22	23			26	27	28								
22	MACHINE CLAMP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17									26	27	28								
23	TURNBUCKLE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28								
24	PILLOW BLOCK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29							
25	MONKEY WRENCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29				33^{W}			
26	S WRENCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28								
27	STILLSON WRENCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29							

REALATED DRAFTING KNOWLEDGE

		A HISTORY OF DRAWING	B DRAFTING MATERIALS	C HISTORY OF PENCIL MAKING	D HISTORY OF MEASUREMENT	E USE OF FRACTIONS	F HISTORY OF ANGLES	G TYPES AND KINDS OF LINES VISIBLE OUTLINE	H TYPES AND KINDS OF LINES HIDDEN OUTLINE	I TYPES AND KINDS OF LINES VISIBLE CENTER LINES	J TYPES AND KINDS OF LINES EXTENSION LINES	K TYPES AND KINDS OF LINES CROSS SECTION LINES	L METHODS OF DIMENSIONING FROM BASE	M METHODS OF DIMENSIONING FROM CENTER	N METHODS OF DIMENSIONING FROM FINISHED SURFACE	O METHODS OF DIMENSIONING OVERALL DIMENSIONS	P METHODS OF DIMENSIONING LOCATING CIRCLES	Q USE OF STANDARD CROSS SECTION	R DETAILS OF CROSS SECTION	S CLASS OF THREAD FITS	T SECTION OF STANDARD PARTS	U USE OF DECIMALS	V METHODS OF MANUFACTORY	W THREADS FORMS STANDARD	X PROPERTIES OF METALS CAST IRON BRASS BRONZE	Y METHODS OF FINISHING LATHE	Z METHODS OF FINISHING MILLER	AA METHODS OF FINISHING GRINDER	BB METHODS OF FINISHING FOUNDRY	CC METHODS OF FINISHING DROP FORGING	DD METHODS OF FINISHING DRILL PRESS	EE SELECTION OF AUXILIARY	FF PIPE THREADS	GG PATTERN MAKING	HH FOUNDRY	II STANDARD TAPERS	JJ GEAR NOMENCLATURE
24	PILLOW BLOCK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29							
25	MONKEY WRENCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29				33^{GG}			
26	S WRENCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28								
27	STILLSON WRENCH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29							
28	ENGINE CRANK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29			32				
29	FIVE ARM PULLEY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28								
30	INSIDE CALIPERS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29						35	
31	SWING CHECK VALVE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28			31	32^{FF}		34^{H}		
32	STEAM RADIATOR VALVE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28								
33	DETAILS GATE VALVE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29		31		33			
34	STUFFING BOX	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30					35	
35	DRILL CHUCK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29						35^{II}	
36	SPUR GEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30						36^{JJ}

CODE
1 2 3 ETC. OPERATING STEPS
A B C ETC. SHOP KNOWLEDGE

REFERENCE
1 SHOP KNOWLEDGE
2 TRADE KNOWLEDGE
3 A.S.A. STANDARD DRAFTING ROOM PRACTICE
4 MACHINE HANDBOOK
5 MECHANICAL DRAFTING BOOK
6 CATALOGS

LESSON 1

PLACING PAPER ON BOARD

TOOLS AND EQUIPMENT

Drawing Board
Drawing Paper

MATERIALS

Drafting Materials

OPERATING POINTS

1. Use drawing board
2. History of drawing
3. Material--soft pine of bass wood
4. Sizes of boards

RELATED INFORMATION

1. History of wood
2. Exhibits
3. Drafting materials catalogues
4. Visual aids

LESSON 2

SQUARING PAPER

TOOLS AND EQUIPMENT

Drawing Board
T Square

MATERIALS

Drafting Materials

OPERATING POINTS

1. Term names for T Square (Heal & Blade)

2. Use top edge of the blade of the T Square

3. Use only for horizontal lines

RELATED INFORMATION

1. History of drawing equipment

2. Manufacturing of drafting materials

3. Visual aids
    - Movies
    - Posters
    - Books
    - Catalogues

LESSON 3

SHARPEN PENCILS

TOOLS AND EQUIPMENT

2H & 4H Pencils

MATERIALS

Drafting Materials

OPERATING POINTS

1. How to sharpen pencil
2. Method of holding pencil

RELATED INFORMATION

1. Correct degrees for use of various work
2. History of pencil
3. Making of a pencil
4. Where material comes from
5. Exhibits
6. Visual aids

LESSON 4

LAYOUT SHEET

TOOLS AND EQUIPMENT

Drawing Board
T Square
Paper
Pencils
Scales
Angles

MATERIALS

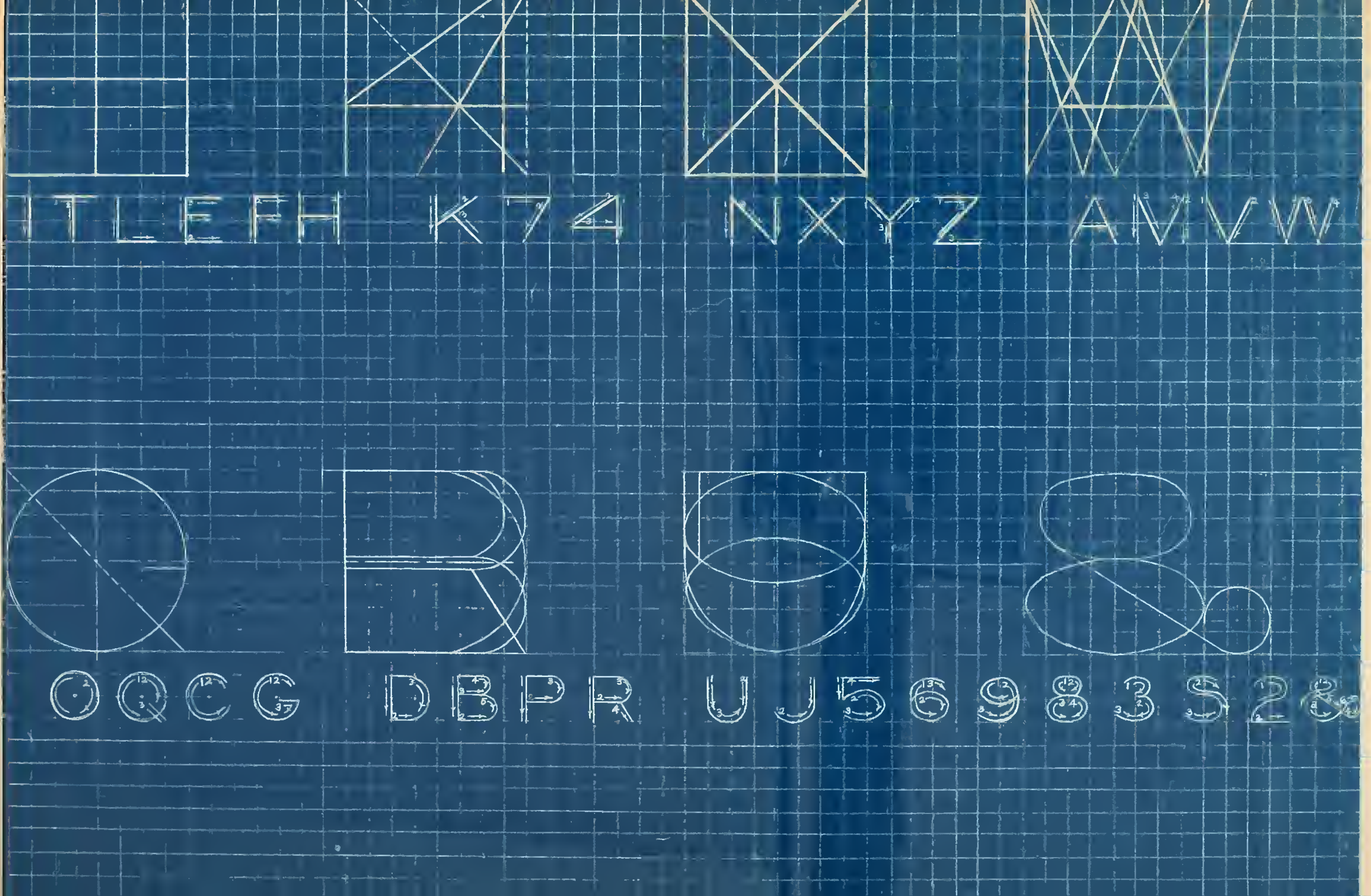
Drafting Materials

OPERATING POINTS

1. Measuring
2. Testing with T Square
3. Drawing vertical & horizontal lines

RELATED INFORMATION

1. Using top blade of T Square
2. Working edge of drawing board


ITLEFH K74 NXYZ AMVW
OQCG DBPR UJ5698 3S2&

LESSON 5

LETTERING

TOOLS AND EQUIPMENT

Drawing Board
2H Pencil
Graft Paper

MATERIALS

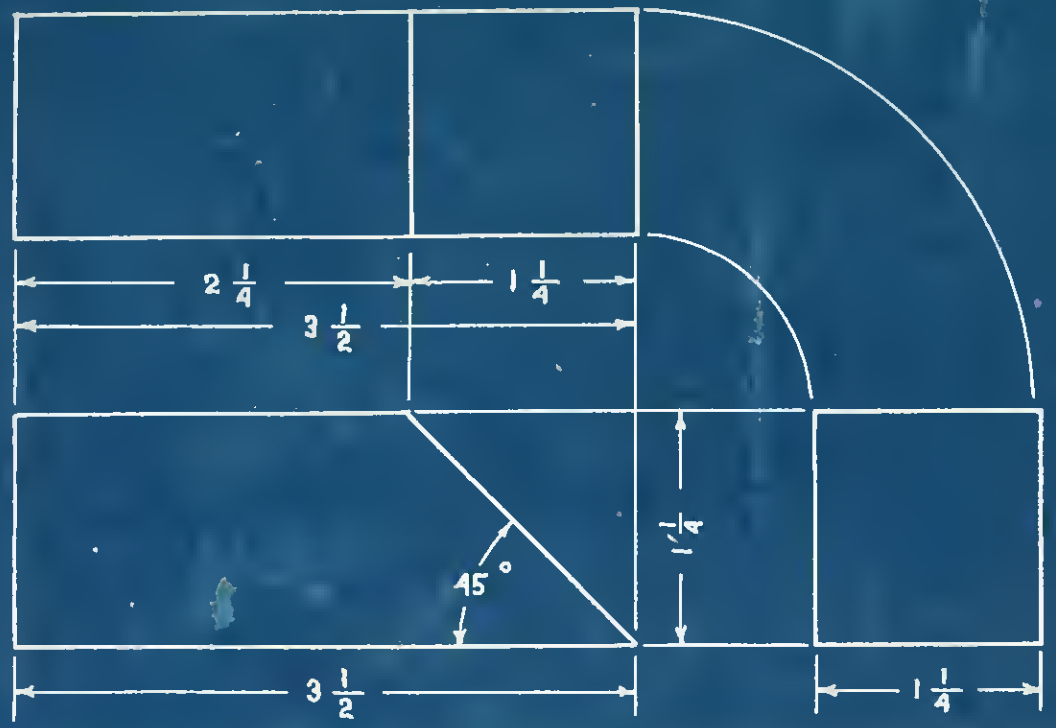
Drafting Materials

OPERATING POINTS

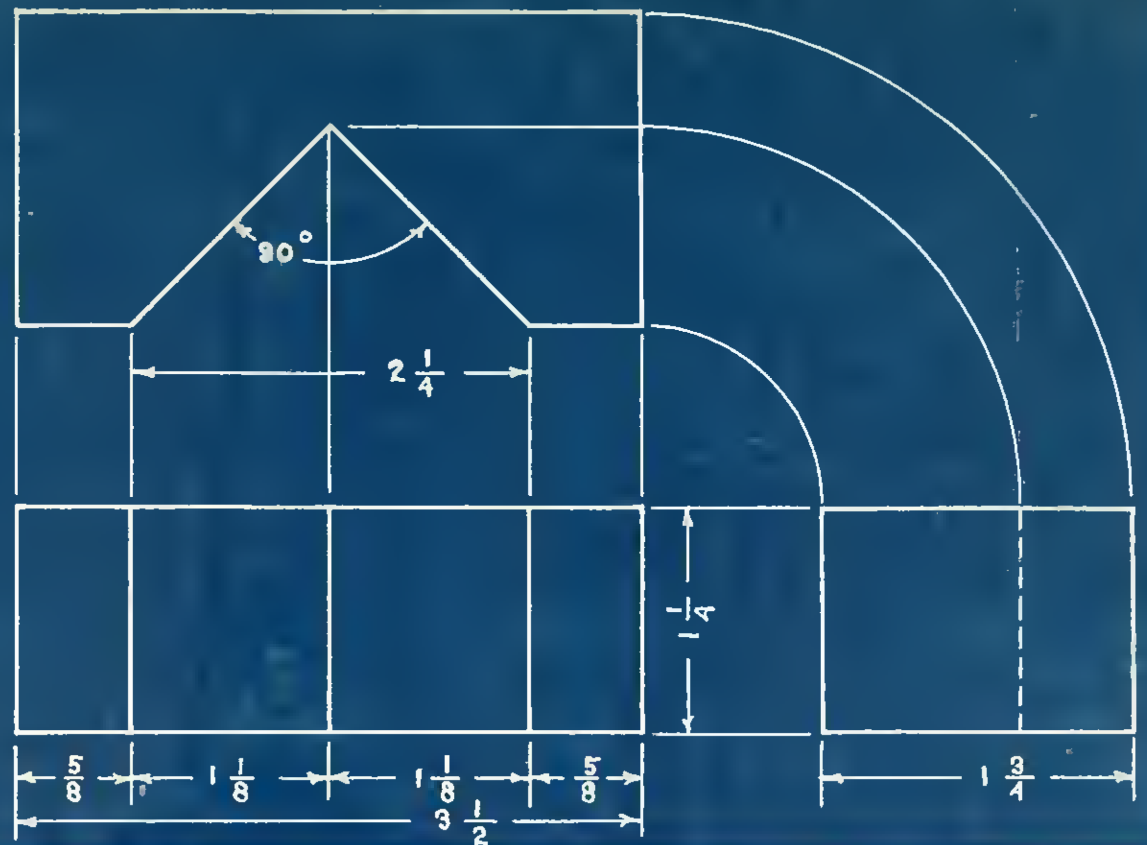
1. Drawing board
2. 2H Pencil
3. Paper
4. Type of letters

RELATED INFORMATION

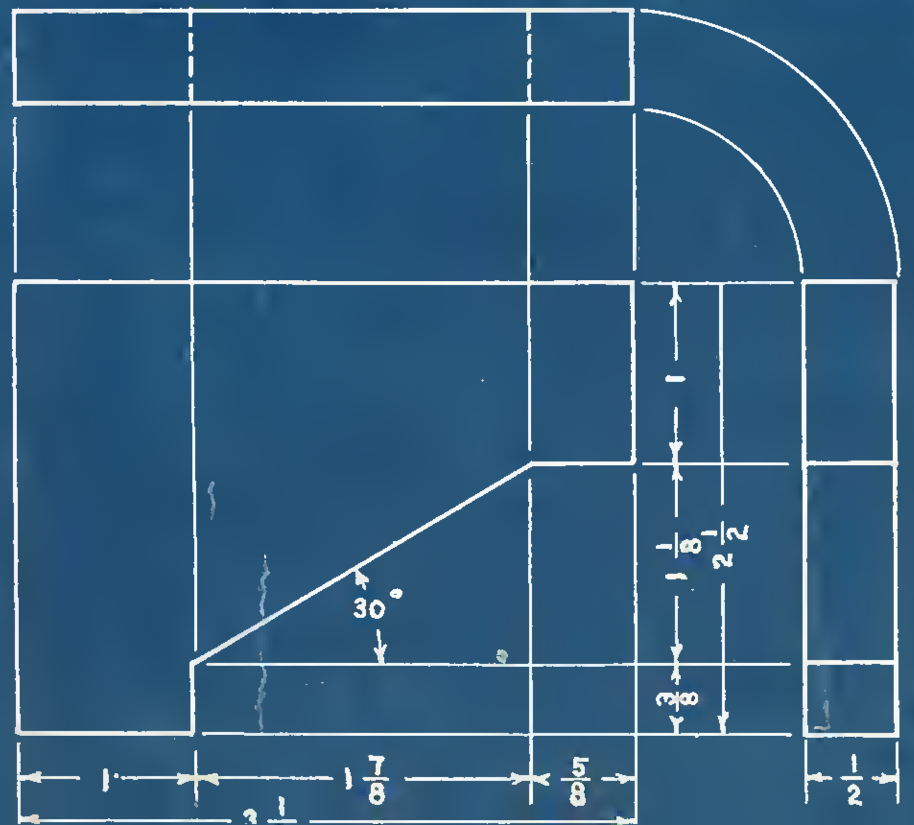
1. History of the alphabet
2. Commercial guides for lettering
3. Early sample of letter



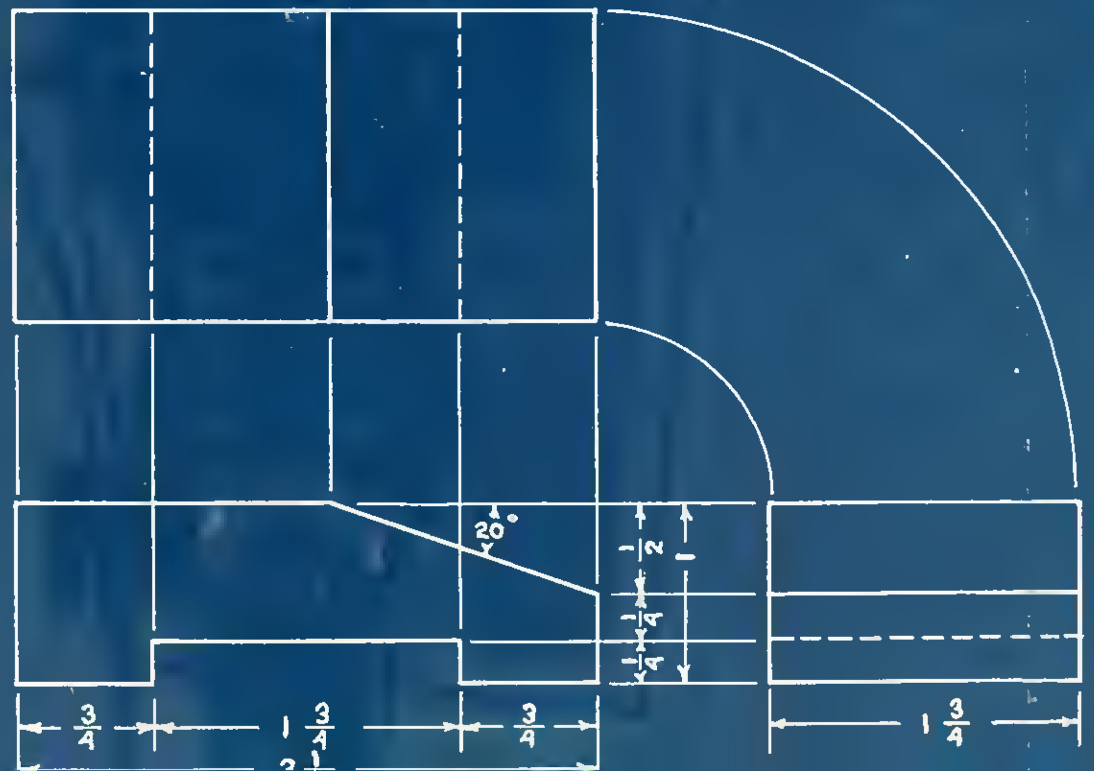
2 1/4
1 1/4
3 1/2
45°
1 1/4
3 1/2
1 1/4



90°
2 1/4
1 1/4
5/8
1 1/8
1 1/8
5/8
3 1/2
1 3/4



1
1 1/8
2 1/2
3/8
30°
1
1 7/8
5/8
1/2



20°
1/2
1
1/4
1/4
3/4
1 3/4
3/4
1 3/4

LESSON 6

BLOCKS

TOOLS AND EQUIPMENT

Drawing Board
T Square
Pencil
Drawing Paper
Drawing Instrument
Scale

MATERIALS

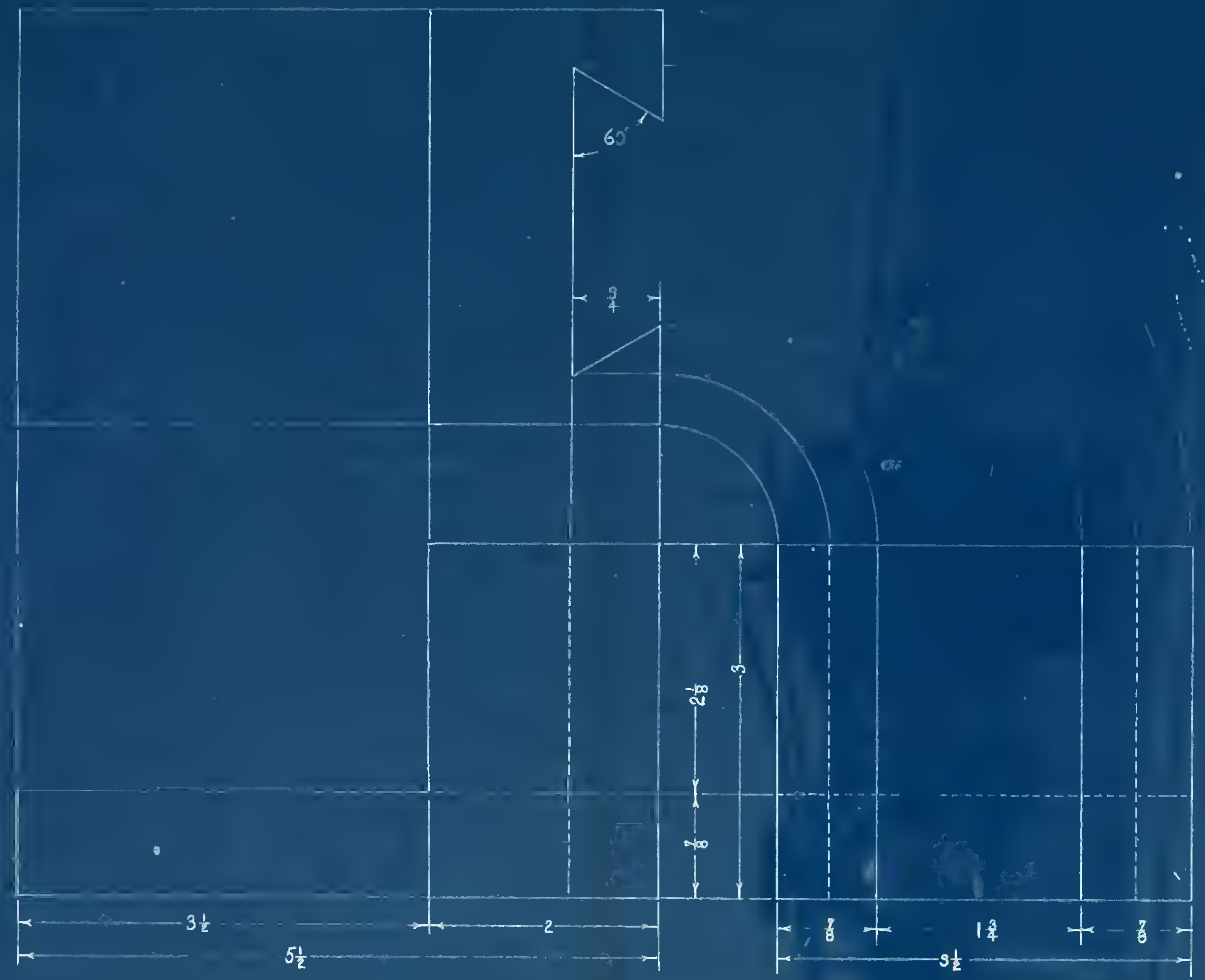
Drafting Materials

OPERATING POINTS

1. Orthographic projection
2. Selection of views
3. Dimension

RELATED INFORMATION

1. Early methods of projection
2. Manipulating triangles
3. Angles



LESSON 7

CAST IRON DOVETAIL

TOOLS & EQUIPMENT

Drawing Board
T Square
Pencil
Drawing Paper
Drawing Instrument
Scale

MATERIALS

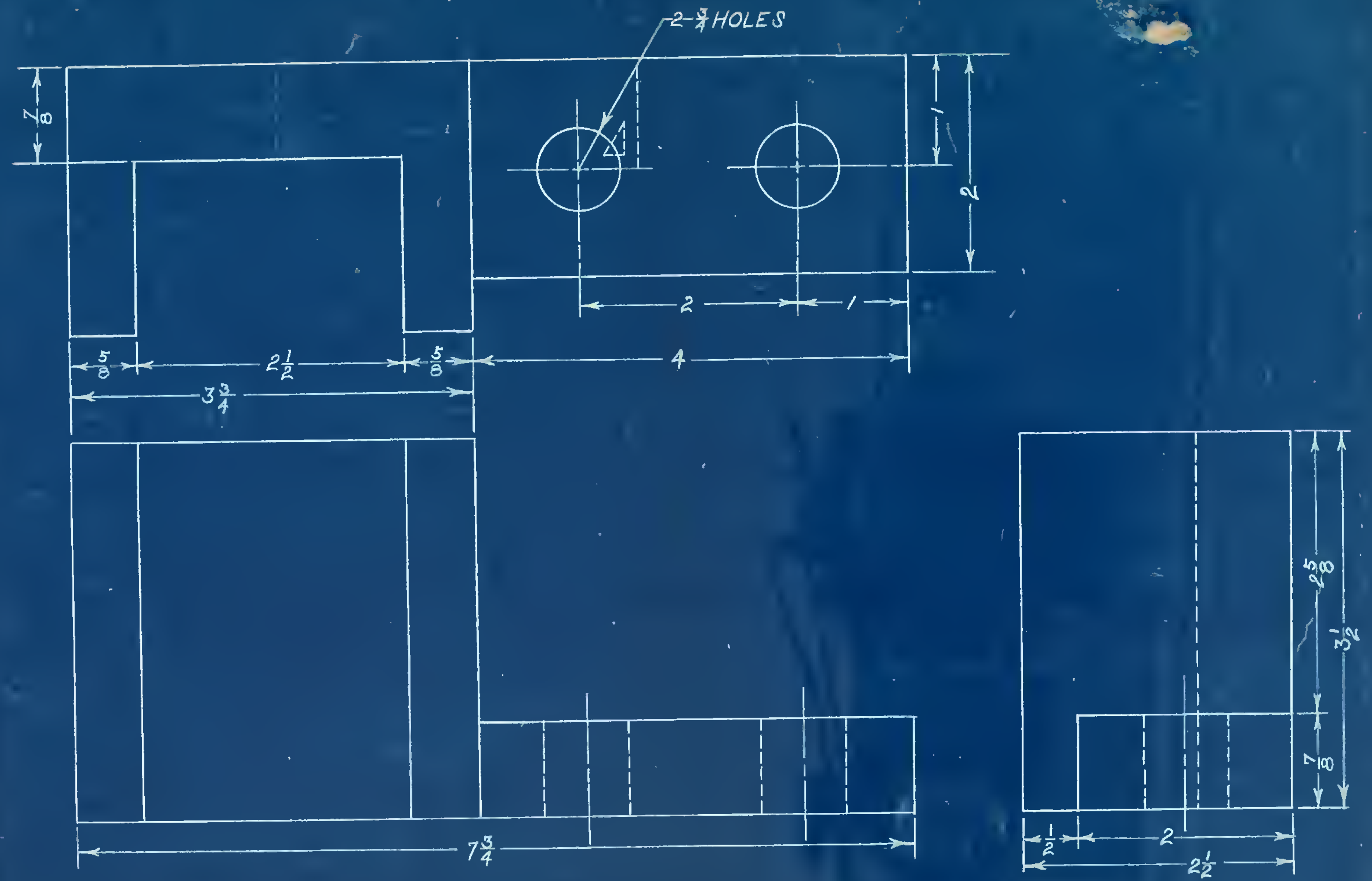
Drafting Materials

OPERATING POINTS

1. Centering drawing on sheets
2. Character of lines
3. Use of angles

RELATED INFORMATION

1. Drawing horizontal, vertical, and angular lines
2. Types and kinds of lines
3. Visible outline



LESSON 8

VERTICAL HOLDING BLOCK

TOOLS AND EQUIPMENT

Drawing Board
T Square
Pencil
Drawing Paper
Drawing Instrument
Scale

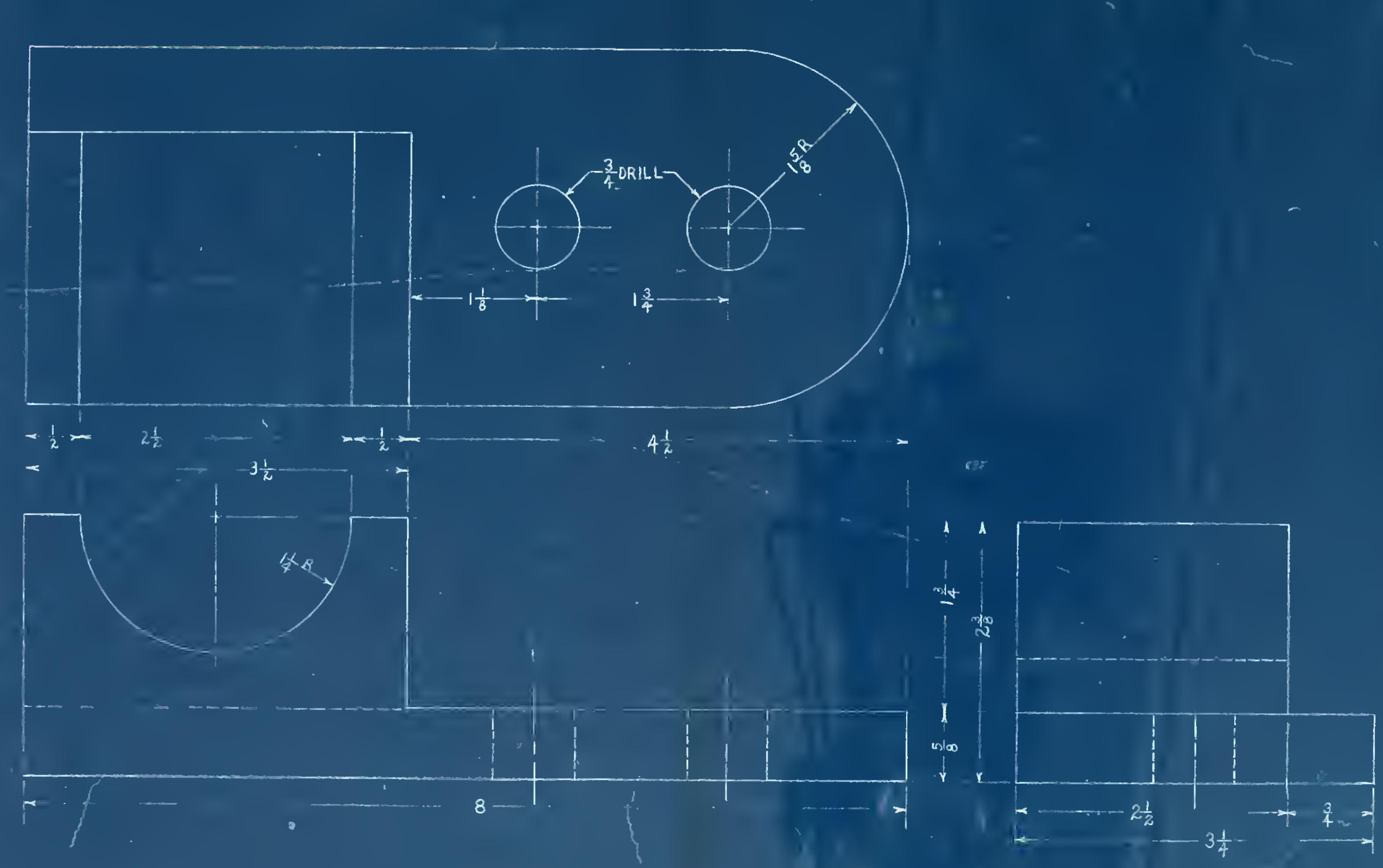
OPERATING POINTS

1. Drawing small circles with bow pencil compass
2. Types and kinds of lines
3. Visible outline

RELATED INFORMATION

Angles--Trigonometric Functions
In a right-angle triangle:-

1. Sine $\frac{\text{Side opposite}}{\text{Hypotenuse}}$
2. Cosine $\frac{\text{Side adjacent}}{\text{Hypotenuse}}$
3. Tangent $\frac{\text{Side opposite}}{\text{Side adjacent}}$
4. Cotangent $\frac{\text{Side adjacent}}{\text{Side Opposite}}$
5. Secant $\frac{\text{Hypotenuse}}{\text{Side adjacent}}$
6. Cosecant $\frac{\text{Hypotenuse}}{\text{Side opposite}}$



3/4 DRILL
1 5/8 R
1 1/8
1 3/4
1/2
2 1/2
1/2
4 1/2
3 1/2
1 1/4 R
1 3/4
2 3/8
5/8
8
2 1/2
3/4
3 1/4

LESSON 9

HORIZONTAL GUIDE

TOOLS AND EQUIPMENT

Drawing Board
T Square
Pencil
Drawing Paper
Drawing Instrument
Scale

MATERIALS

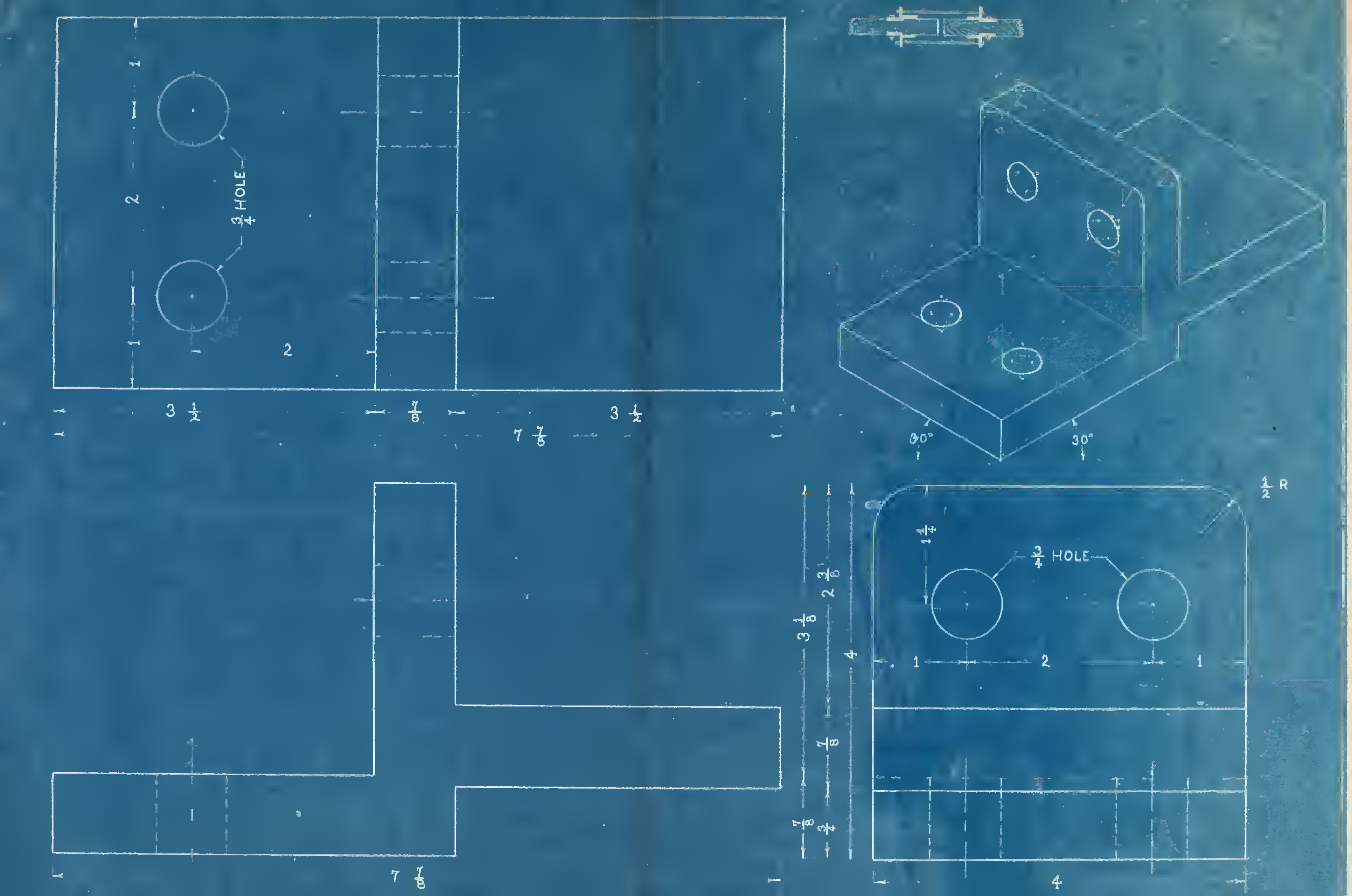
Drafting Materials

OPERATING POINTS

1. Drawing arc with large compass
2. Types and kinds of lines
3. Visible center lines

RELATED INFORMATION

1. Geometrical constructions
2. Cylinders
   Cones


3/4 HOLE
2
1
2
3 1/2
7/8
3 1/2
7 7/8
30°
30°
1/2 R
1 1/4
3/4 HOLE
1
2
1
3 1/8
2 3/8
4
7/8
7/8
3/4
7 7/8
4

LESSON 10

SPLICE PLATE

TOOLS AND EQUIPMENT

- Drawing Board
- T Square
- Pencil
- Drawing Paper
- Drawing Instrument

MATERIALS

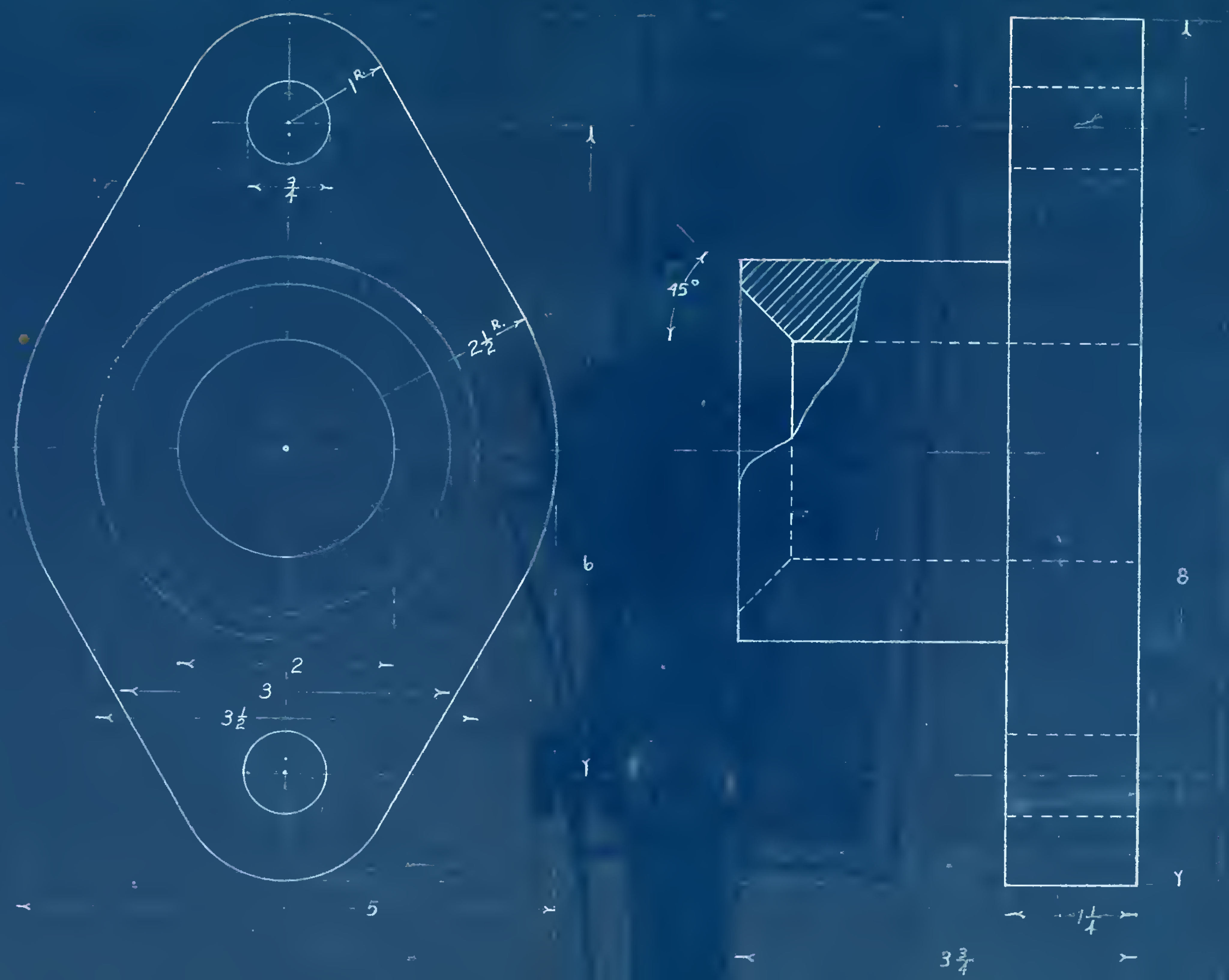
- Drafting Materials

OPERATING POINTS

1. Invisible lines for holes
2. Isometric layout

RELATED INFORMATION

1. Pictorial drawing
2. Axonometric
3. Dimetric
4. Isometric
5. Oblique
6. Cabinet
7. Cavalier
8. Perspective



LESSON 11

STUFFING GLAND

TOOLS AND EQUIPMENT

Drawing Board
T Square
Pencil
Drawing Paper
Scale

MATERIALS

Drafting Materials

OPERATING POINTS

1. Making tangent curves
2. Types and kinds of lines
3. Cross section lines

RELATED INFORMATION

A. Types of Drills
  1. Taper shank--carbon steel--high speed steel
  2. Straight shank--carbon steel--high speed steel
    a. Three flute
    b. Four groove
  3. Taper square shank
  4. Center drills
  5. Core drills

B. Types of Reamers
  1. Hand
    a. Eccentric flutes
    b. Spiral flutes
  2. Chucking
    a. Straight shank
    b. Taper shank
    c. Rose
  3. Sheel
    a. Straight flutes
    b. Spiral flutes
  4. Taper pin

LESSON 12

PIPE ELBOW

TOOLS AND EQUIPMENT

- Drawing Board
- T Square
- Pencil
- Drawing Paper
- Drawing Instrument
- Scale

MATERIALS

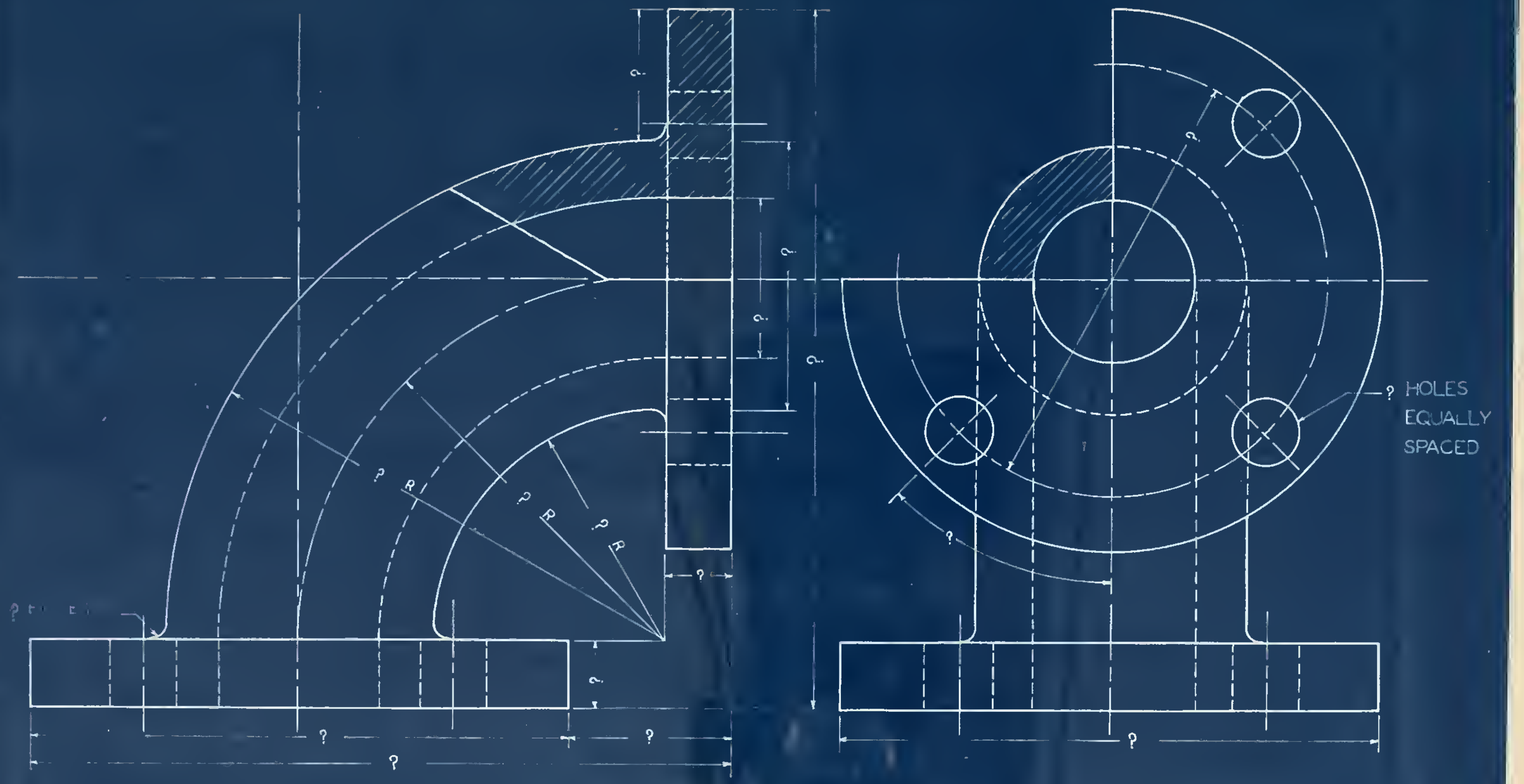
- Drafting Materials

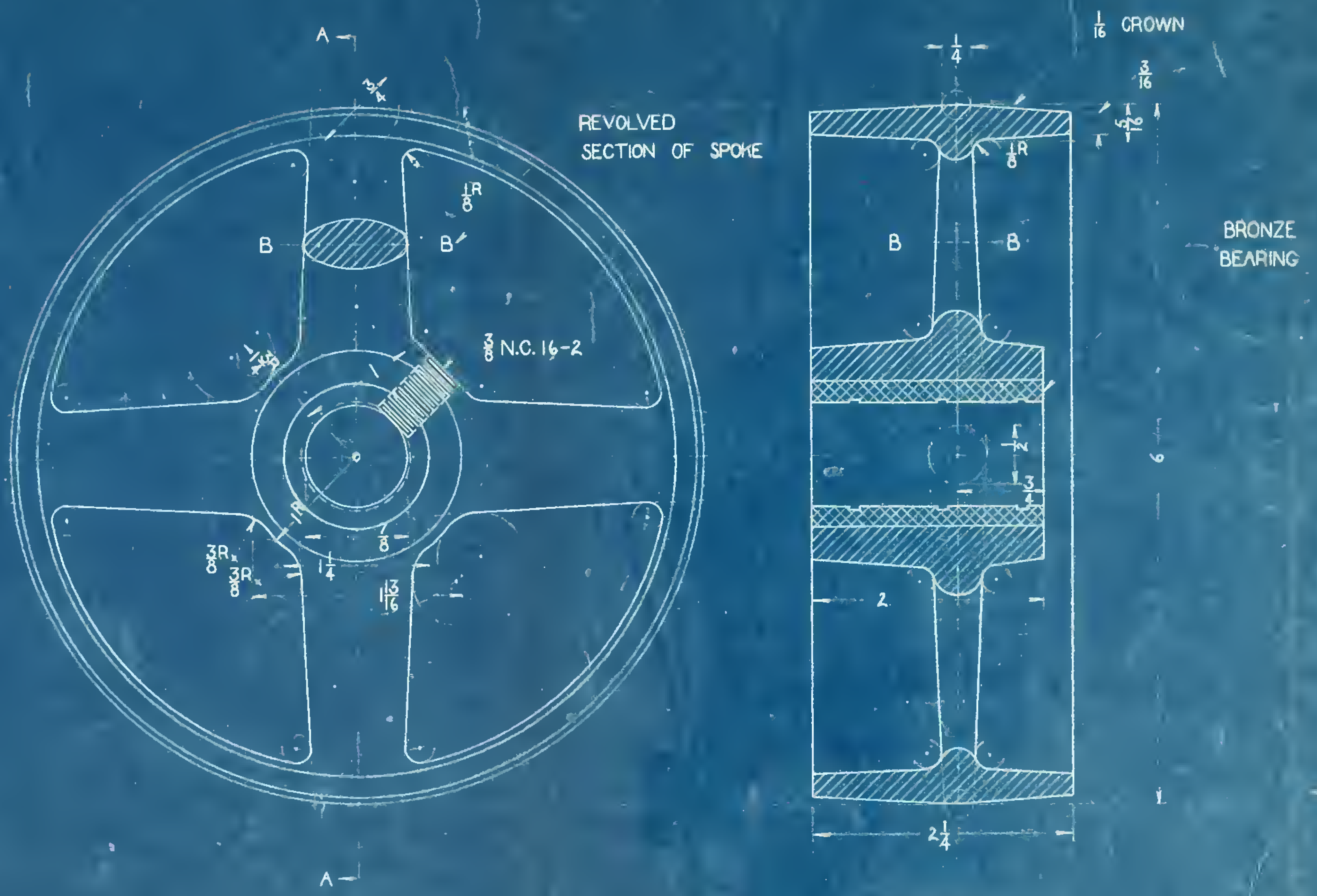
OPERATING POINTS

1. Layout sheet
2. Space views
3. Block in necessary views and sections
4. Layout shape of object in the views and sections
5. Layout dimension and witness lines
6. Reline-object, dimension, witness, and reference lines
7. Dimension and letter

RELATED INFORMATION

1. Using Calipers to get dimensions
2. Methods of dimensioning from base




A
3/4
REVOLVED SECTION OF SPOKE
B
B
1/8 R
3/8 N.C. 16-2
1/4
1 1/2
7/8
3R/8
3R/8
1 1/4
1 13/16
A
1/16 CROWN
1/4
3/16
5/16
1/8 R
B
B
BRONZE BEARING
1/2
3/4
6
2
2 1/4

LESSON 13

4 ARM PULLY

TOOLS & EQUIPMENT

- Drawing Board
- T Square
- Pencil
- Drawing Paper
- Drawing Instrument
- Scale

MATERIALS

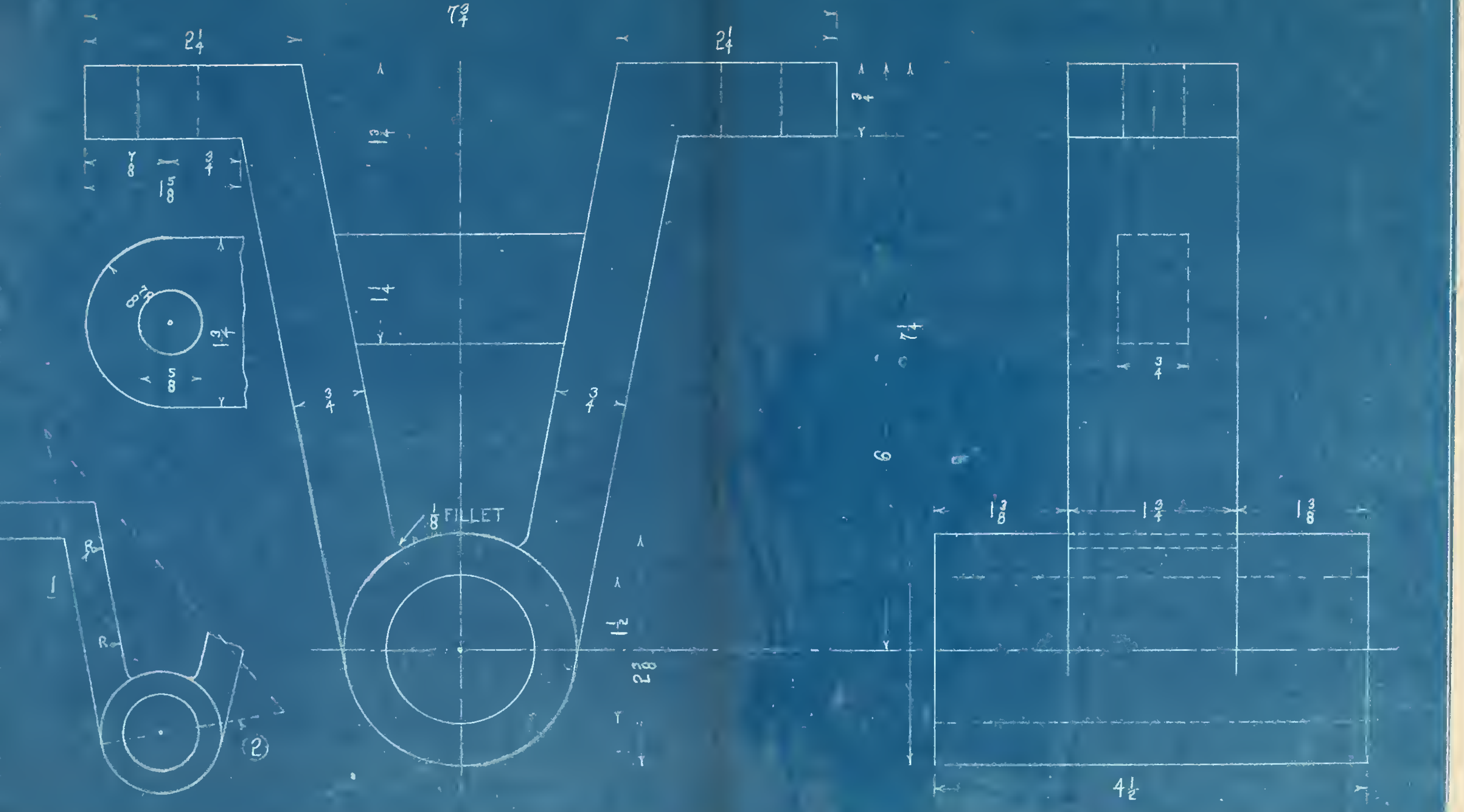
- Drafting Materials

OPERATING POINTS

1. Making sections
2. Study of Materials
3. Methods of dimensioning from center

RELATED INFORMATION

1. Wood for patterns
   - a. White pine
   - b. Mahogany
   - c. Cherry
   - d. Maple
   - e. Birch
   - f. Fir
2. Shrinkage allowances
   - a. Cast iron-3/32 to 1/8 inch per foot
   - b. Brass -3/16 to 1/8 " " "
   - c. Bronze -5/32 to 1/8 " " "
   - d. Aluminum -7/32 to 1/4 " " "
   - e. Steel -3/16 to 1/4 " " "
3. Draft
   - a. 1/8 inch per foot for each foot of surface to be drawn
4. Types of patterns
   - a. Wood
   - b. Metal
   - c. Single
   - d. Cored
   - e. Split
   - f. Gang
5. Exhibits of Patterns


7 3/4
2 1/4
2 1/4
3/4
1 3/4
7/8
3/4
1 5/8
3/8 R
3/4
5/8
1 1/4
3/4
3/4
7 1/4
6
3/4
1/8 FILLET
R
1
R
1 1/2
2 3/8
1 3/8
1 3/4
1 3/8
4 1/2
(2)

TO DRAW A LINE PARALLEL TO A GIVEN LINE, SET RADIUS TO 3/4

TO GET A POINT OF TANGENCY WITH A STRAIGHT LINE TO A CIRCLE, FIX THE TWO POINTS AS SHOWN

LESSON 14

SHAFT HANGER

TOOLS AND EQUIPMENT

- Drawing Board
- T Square
- Pencil
- Drawing Paper
- Drawing Instrument
- Scale

MATERIALS

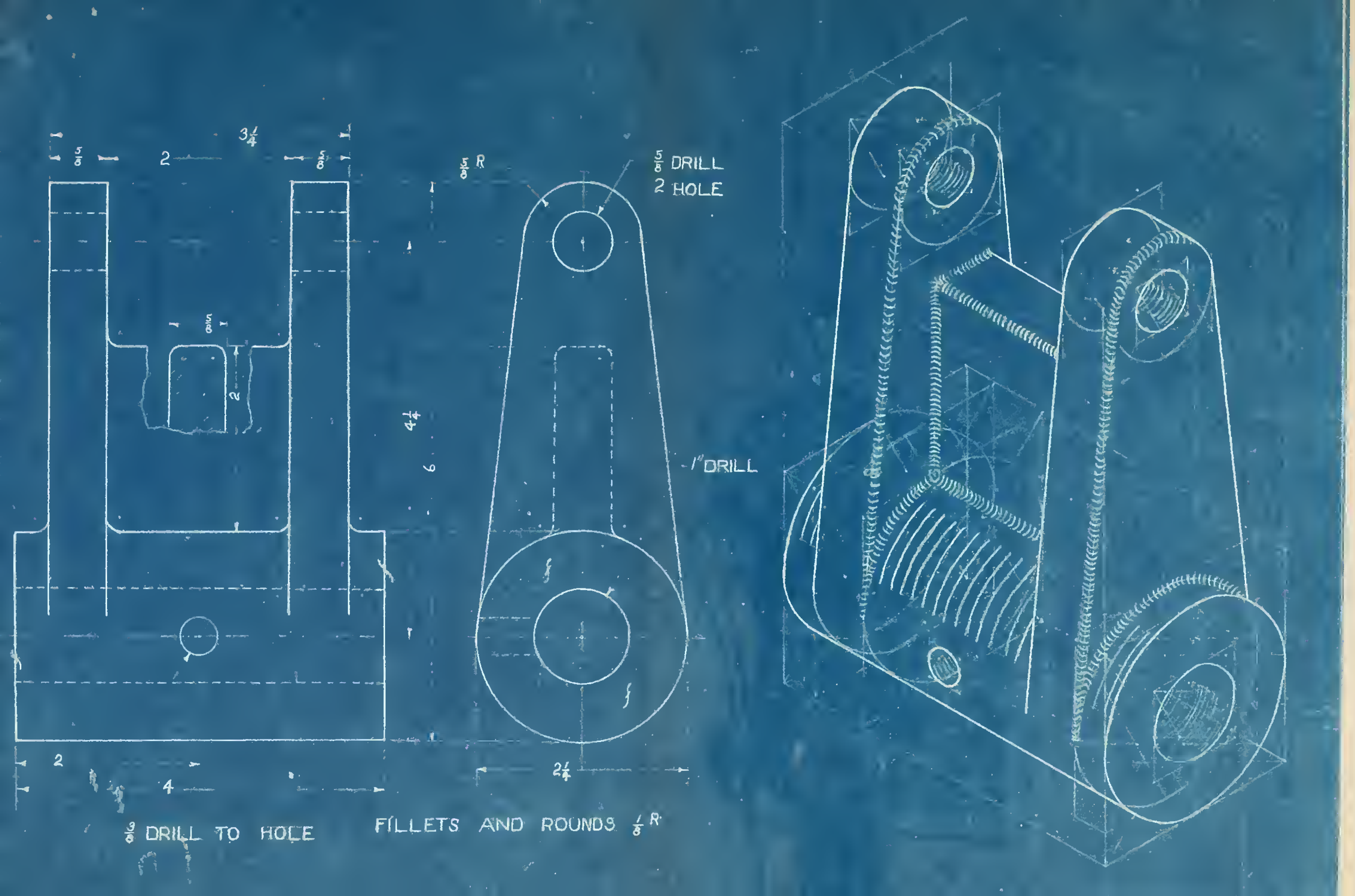
- Drafting Materials

OPERATING POINTS

1. Using Large Compass
2. Methods of dimensioning from finished surface

RELATED INFORMATION

1. Casting
2. Rooling
3. Drawing
4. Machining
5. Forming
6. Extruding
7. Die Casting
8. Forging


3 1/4
5/8
2
5/8
5/8
2
5/8 R
5/8 DRILL
2 HOLE
4 1/4
6
1" DRILL
2
4
2 1/4
3/8 DRILL TO HOLE
FILLETS AND ROUNDS 1/8 R

LESSON 15

ROCKER ARM

TOOLS AND EQUIPMENT

- Drawing Board
- T Square
- Pencil
- Drawing Paper
- Drawing Instrument
- Scale

MATERIALS

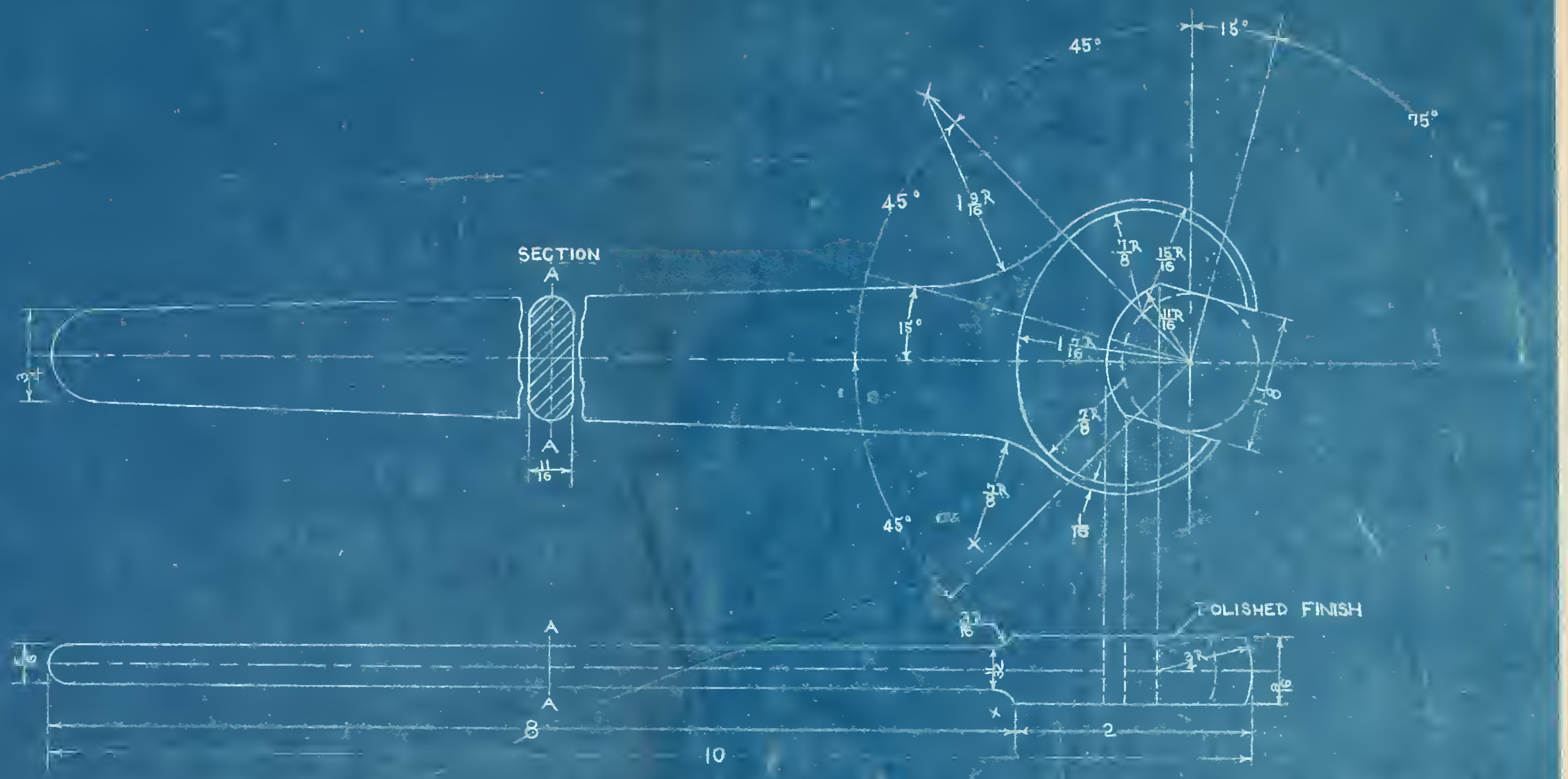
- Drafting Materials

OPERATING POINTS

1. Isometric
2. Methods of dimensioning overall

RELATED INFORMATION

1. Iron ore
2. Pig iron
   a. Bessemer Pig
   b. Basic "
   c. Malleable "
   d. Foundry "
3. Puddling process
4. Bessemer "
5. Open hearth "
6. Crucible "
7. Electric furnace


SECTION
A
A
11/16
45°
15°
75°
45°
1 9/16 R
7/8 R
15/16 R
11/16 R
15°
1 7/16 R
1 7/8
7/8 R
7/8 R
45°
1/16
3/4
3/16 R
POLISHED FINISH
3/4 R
5/8
5/16
A
A
8
2
10

LESSON 16

OPERATION

FORK WRENCH

TOOLS AND EQUIPMENT

- Drawing Board
- T Square
- Pencil
- Drawing Paper
- Drawing Instrument
- Scale

MATERIALS

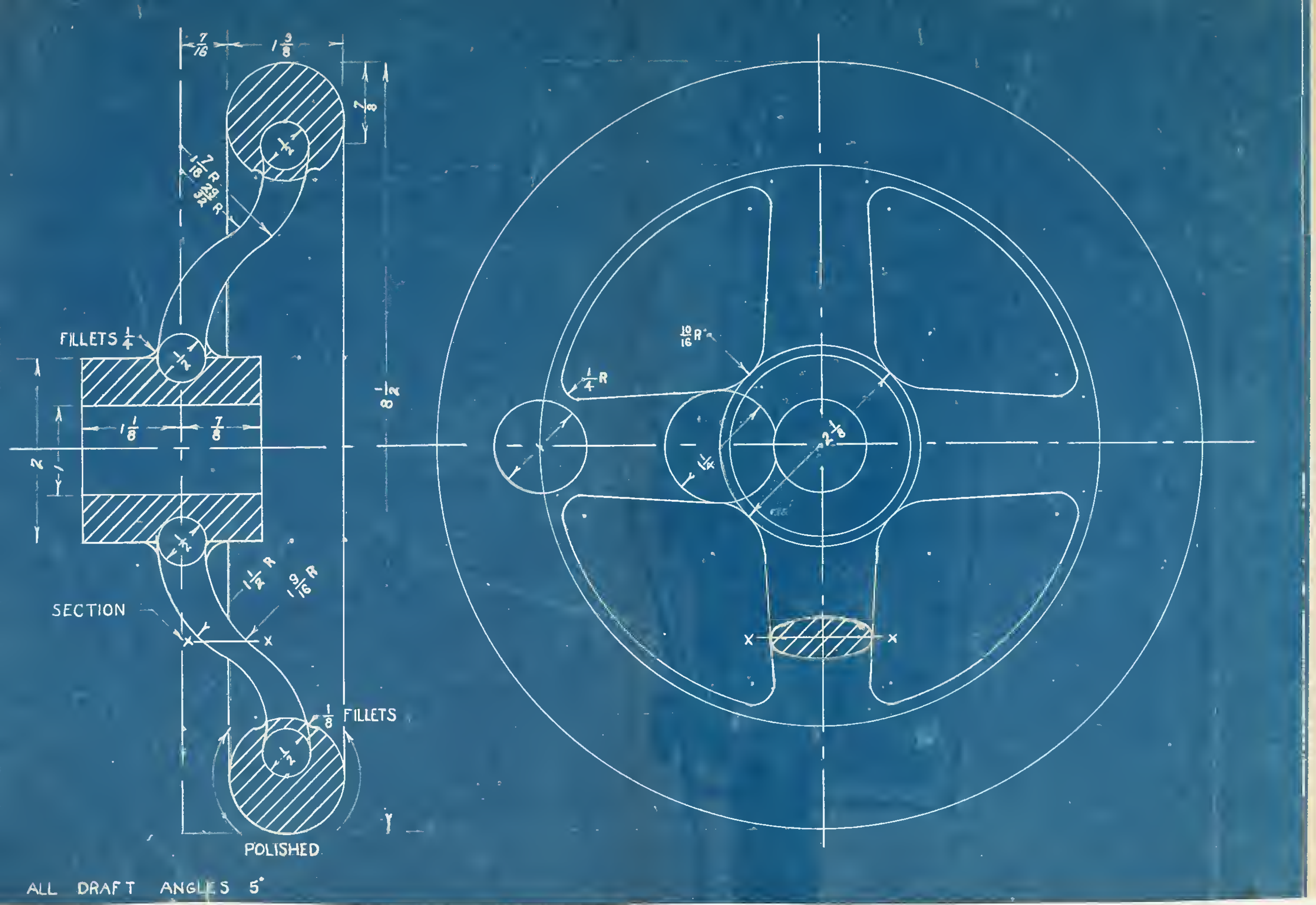
- Drafting Materials

OPERATING POINTS

1. Protractor
2. Methods of dimensioning
   Locating circles

RELATED INFORMATION

1. Analyze problem
2. Determine necessary triangles
3. Choose angular function
4. Look up value of function
   in tables
5. Substitutes value of function
6. Solve formula


7/16
1 3/8
7/8
1/2
7/16 R
29/32 R
FILLETS 1/4
1/2
8 1/2
1 1/8
7/8
2
1
1/2
1 1/2 R
1 9/16 R
SECTION
X
X
1/2
1/8 FILLETS
POLISHED
ALL DRAFT ANGLES 5°
10/16 R
1/4 R
1 1/4
2 1/8
X
X

LESSON 17

HAND WHEEL

TOOLS AND EQUIPMENT

Drawing Board
T Square
Pencil
Drawing Paper
Drawing Instrument
Scale

MATERIALS

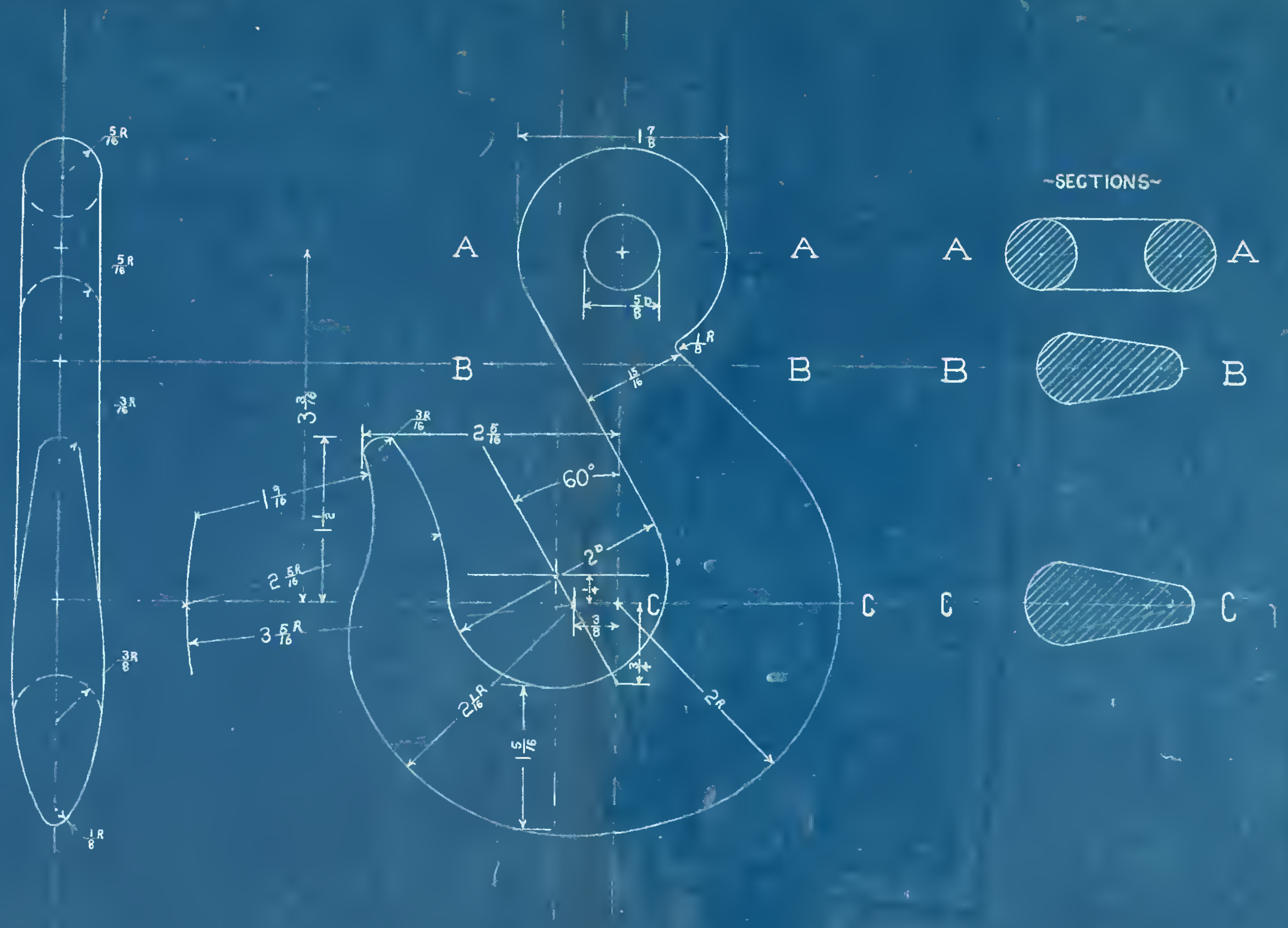
Drafting Materials

OPERATING POINTS

1. Use Handbooks
2. Use of Standard Cross Section

RELATED INFORMATION

1. Cold Rolled Steel-(C.R.S.)
   - a. Any desired shape
   - b. Even fractional sizes
2. Machine Steel-(M.S.)
   - a. Must be machined on working surface
3. Tool Steel-(T.S.)
   - a. Type will depend on use
4. High Speed Steel-(H.S.S.)
5. Steel Castings
6. Cast Iron



-SECTIONS-
A
A
A
A
B
B
B
B
C
C
C
C
$\frac{5}{16}$R
$\frac{5}{16}$R
$\frac{3}{16}$R
$\frac{3}{8}$R
$\frac{1}{8}$R
$1\frac{7}{8}$
$\frac{5}{8}$D
$\frac{1}{8}$R
$\frac{15}{16}$
$3\frac{3}{16}$
$\frac{3}{16}$R
$2\frac{5}{16}$
60°
$1\frac{9}{16}$
$\frac{1}{2}$
$2\frac{5}{16}$R
$3\frac{5}{16}$R
2D
$\frac{1}{4}$
$\frac{3}{8}$
$\frac{3}{4}$
$2\frac{1}{16}$R
$1\frac{5}{16}$
2R

LESSON 18

CRANE HOOK

TOOLS AND EQUIPMENT

Drawing Board
T Square
Pencil
Drawing Paper
Drawing Instrument
Scale

MATERIALS

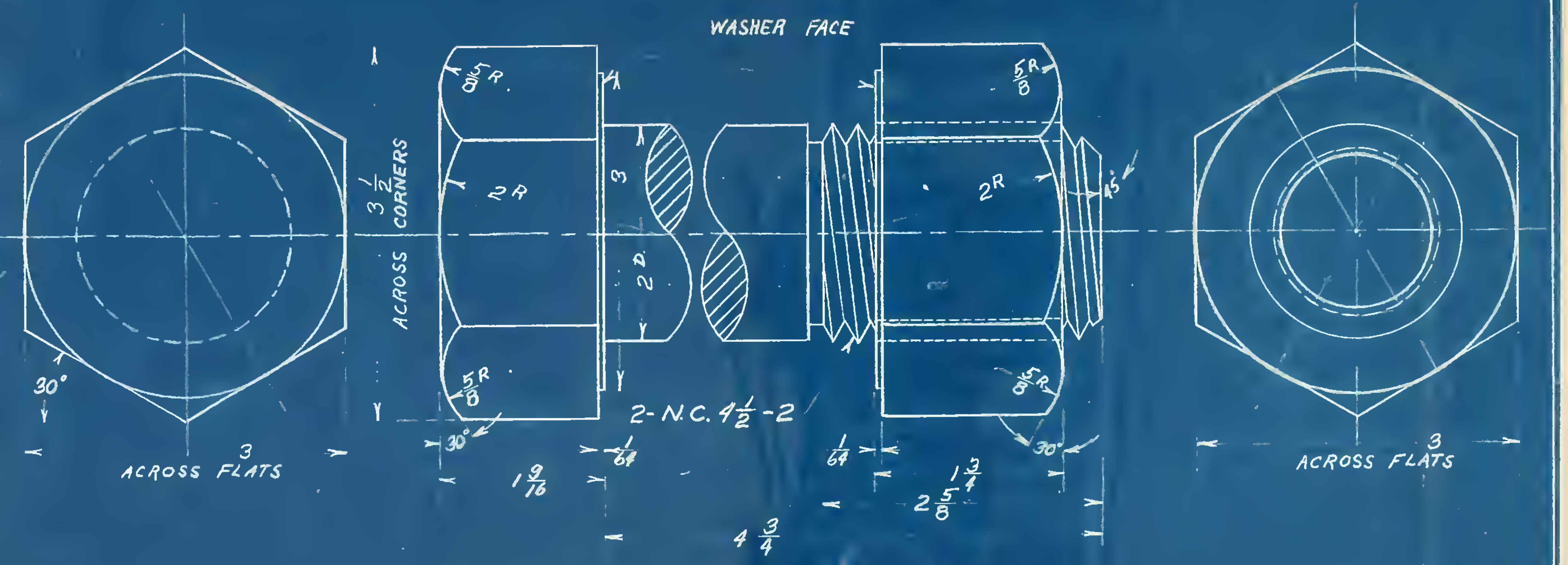
Drafting Materials

OPERATING POINTS

1. Use Catalogs
2. Details of Cross Section

RELATED INFORMATION

1. Layout size of throat
2. Layout angles of different radii
3. Layout of body size
4. Method of sections


WASHER FACE
5/8 R.
2R
3
2 D.
3 1/2 ACROSS CORNERS
30°
3 ACROSS FLATS
30°
2-N.C. 4 1/2 -2
1/64
1 9/16
4 3/4
1/64
1 3/4
2 5/8
5/8 R
2R
45°
30°
3 ACROSS FLATS

LESSON 19

OPERATION

BOLT

TOOLS AND EQUIPMENT

- Drawing Board
- T Square
- Pencil
- Drawing Paper
- Drawing Instrument
- Scale

MATERIALS

- Drafting Materials

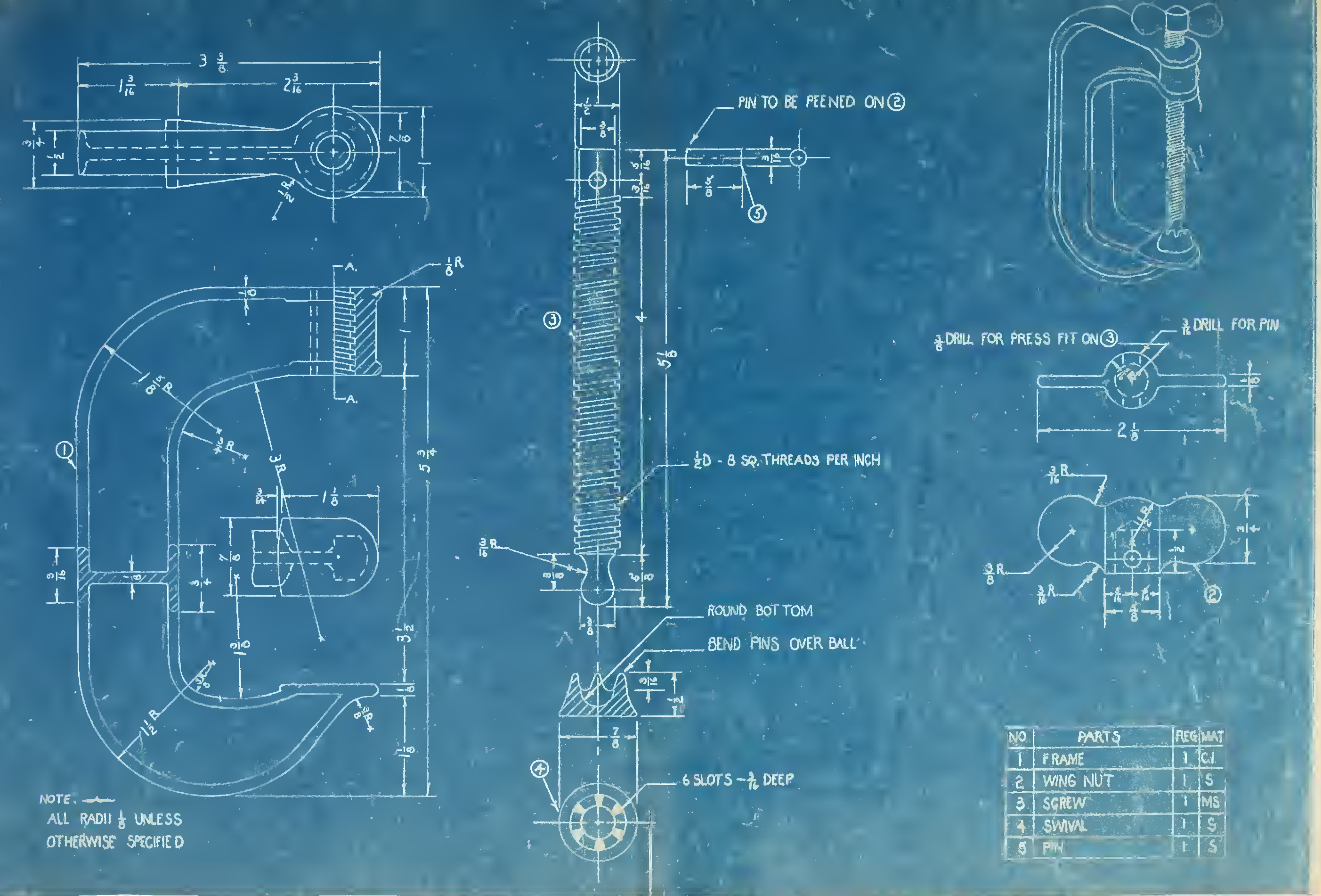
OPERATING POINTS

1. Measuring Threads, Method of Notation
2. Class of Thread Fits

RELATED INFORMATION

A. Screw Thread systems
  1. United States Standard--U. S. S.
    a. National Coarse--N. C.
    b. National Fine--N. F.
  2. Sharp "V"
  3. Whitworth Standard
  4. Standard Pipe--American Briggs
  5. British Association Standard
  6. Square
  7. Acme
  8. Standard Worm
  9. Dardelet Self-locking

B. Measuring threads-methods
  1. Thread micrometer
  2. Three wire method
  3. Projection Method
  4. Thread gages



3 3/8
1 3/16
2 3/16
3/4
1/2
7/8
1
1/2 R
A.
1/8 R
1/8
1
1 5/8 R
3/4 R
3 R
1
3/4
1 1/8
7/8
3/4
3/8
9/16
1 3/8
5 3/4
3 1/2
3/8
1 1/2 R
1/8
3/8 R
1 1/8
1/2
3/8
3/16
3/16
4
5 1/8
3/16
5/16
3
3/16 R
3/8
3/16
3/16
1/2
7/8
4
2 1/8
1/8
3/16 R
3/8 R
3/16 R
3/4
1/2
1/8
1/8
4/8
2

PIN TO BE PEENED ON ②

1/2 D - 8 SQ. THREADS PER INCH

ROUND BOTTOM

BEND PINS OVER BALL

6 SLOTS - 3/16 DEEP

3/8 DRILL FOR PRESS FIT ON ③

3/16 DRILL FOR PIN

NOTE:
ALL RADII 1/8 UNLESS
OTHERWISE SPECIFIED

NO	PARTS	REG	MAT
1	FRAME	1	C.I.
2	WING NUT	1	S
3	SCREW	1	MS
4	SWIVAL	1	S
5	PIN	1	S

LESSON 20

C CLAMP

TOOLS AND EQUIPMENT

Drawing Board
T Square
Pencil
Drawing Paper
Drawing Instrument
Scale

MATERIALS

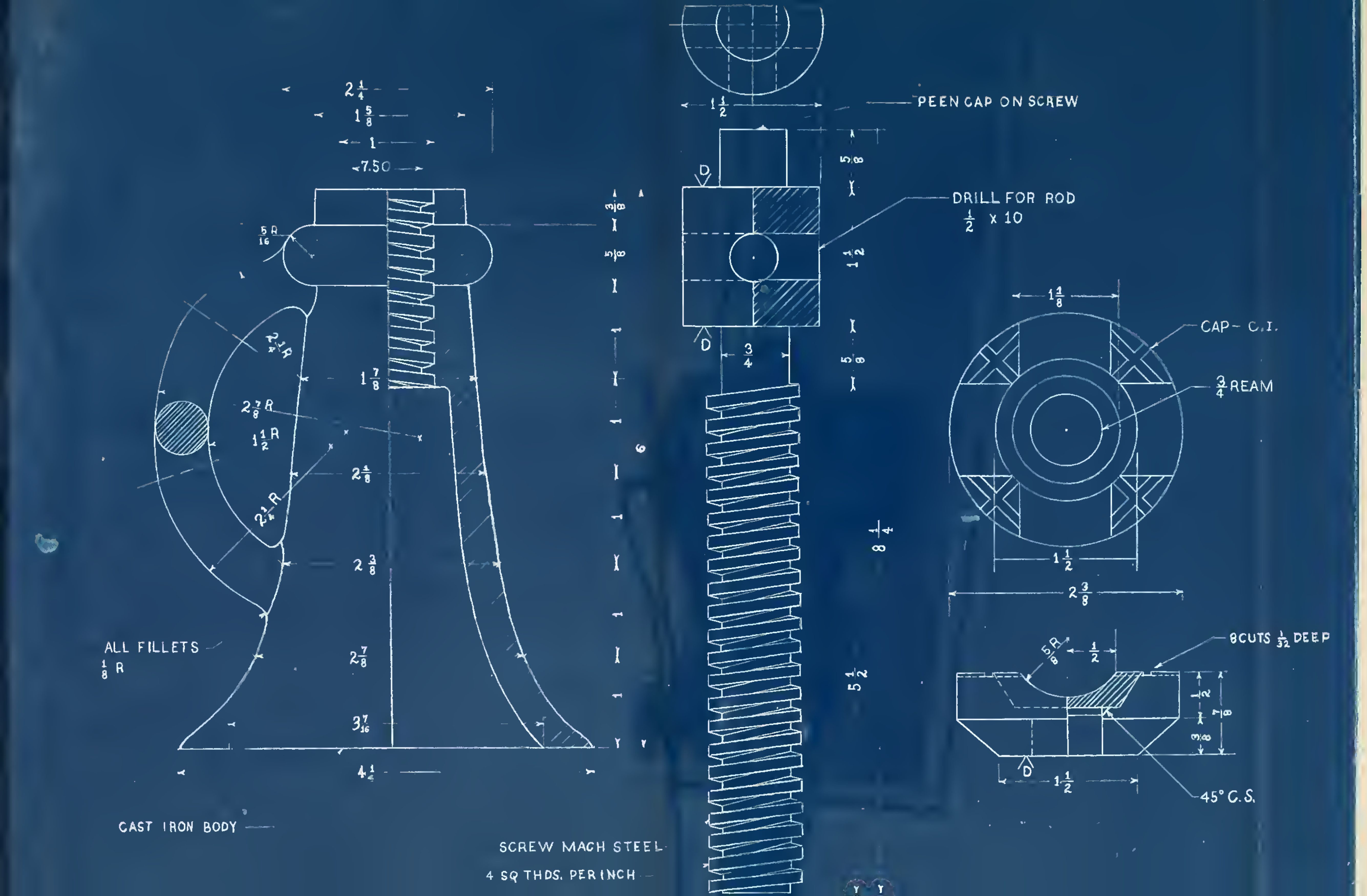
Drafting Materials

OPERATING POINTS

1. Indicating Assembling Procedure
2. Section of Standard Parts

RELATED INFORMATION

1. Layout body diameter
2. Layout body length
3. Layout Screw end--diameter and length
4. Layout head--diameter and thickness
5. Layout scrwdriver slot in head
6. Layout flats for wrench


2 1/4
1 5/8
1
.750
5/16 R
2 1/4 R
2 7/8 R
1 1/2 R
2 1/4 R
1 7/8
2 1/8
2 3/8
2 7/8
3 7/16
4 1/2
3/8
5/8
6
ALL FILLETS 1/8 R
CAST IRON BODY
SCREW MACH STEEL
4 SQ THDS. PER INCH
1 1/2
PEEN CAP ON SCREW
D
D
5/8
1 1/2
3/4
5/8
8 1/4
5 1/2
DRILL FOR ROD 1/2 x 10
1 1/8
CAP - C.I.
3/4 REAM
1 1/2
2 3/8
5/8 R
1/2
8 CUTS 1/32 DEEP
1/2
7/8
3/8
D
1 1/2
45° C.S.

LESSON 21

JACK SCREW

TOOLS AND EQUIPMENT

Drawing Board
T Square
Pencil
Drawing Paper
Drawing Instrument
Scale

MATERIALS

Drafting Materials

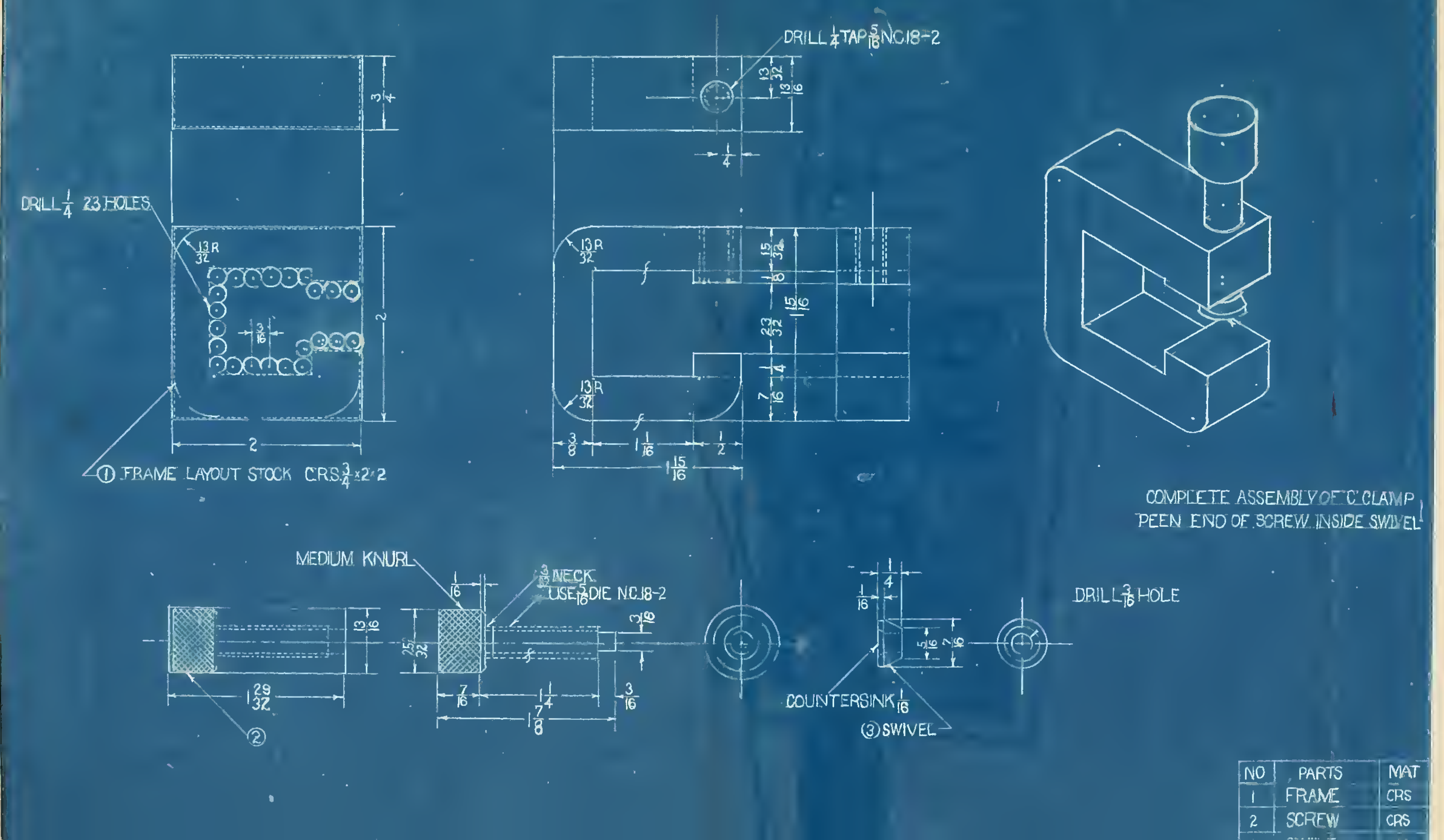
OPERATING POINTS

1. Measuring with Micrometer

2. Use of decimals

RELATED INFORMATION

A. Types of Gages
  1. Plug
  2. Ring
  3. Receiving
  4. Snap
  5. Caliper
  6. Thread
  7. Contour
  8. Dial indicating


DRILL 1/4 TAP 5/16 NC18-2
DRILL 1/4 23 HOLES
13/32 R
13/32 R
13/32 R
3/4
2
2
3/16
13/32
13/16
1/4
15/32
1/8
15/16
23/32
1/4
7/16
3/8
1 1/16
1/2
1 15/16
① FRAME LAYOUT STOCK CRS 3/4 x 2 x 2
COMPLETE ASSEMBLY OF 'C' CLAMP
PEEN END OF SCREW INSIDE SWIVEL
MEDIUM KNURL
1/16
3/32 NECK
USE 5/16 DIE NC18-2
13/16
25/32
3/16
1 29/32
7/16
1 1/4
1 7/8
3/16
②
1/16
1/4
5/16
7/16
COUNTERSINK 1/16
③ SWIVEL
DRILL 3/16 HOLE

NO	PARTS	MAT
1	FRAME	CRS
2	SCREW	CRS

LESSON 22

MACHINE CLAMP

TOOLS & EQUIPMENT

Drawing Board
T Square
Pencil
Drawing Paper
Drawing Instrument
Scale

MATERIALS

Drafting Materials

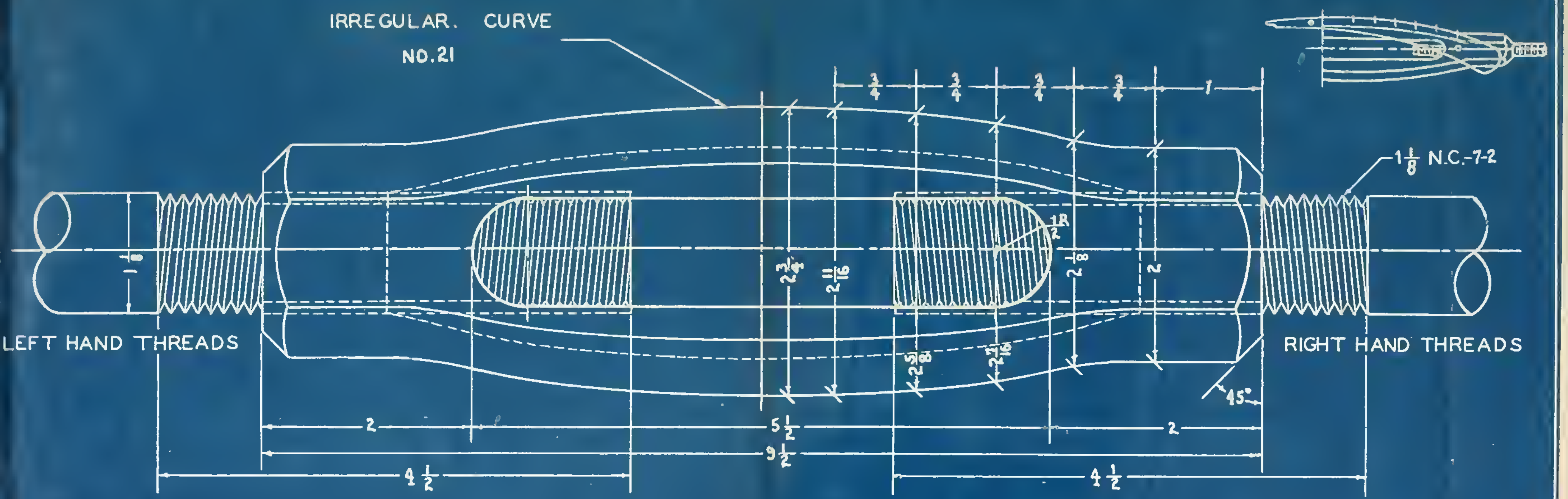
OPERATING POINTS

1. Indicating Machinery Method
2. Methods of Manufactory

RELATED INFORMATION

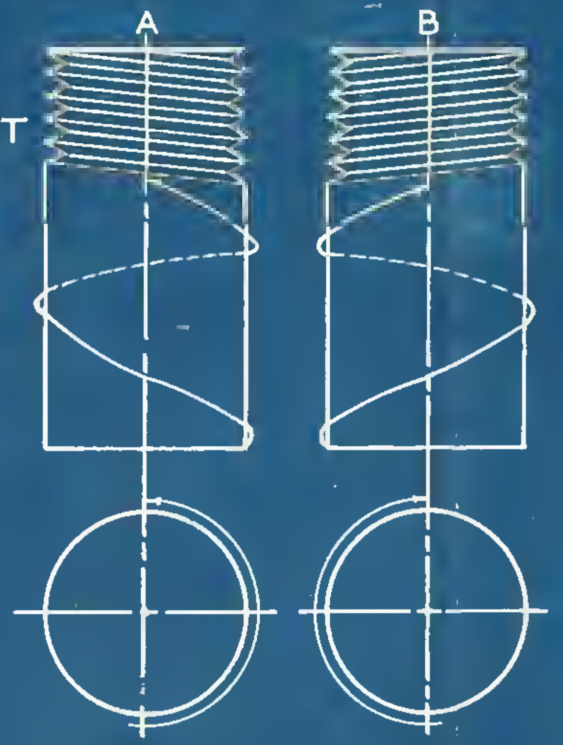
A. Types of Taps
    1. Hand
    2. Adjustable
    3. Collapsable
    4. Combination

B. Types of Dies
    1. Solid square
    2. Solid round
    3. Round split adjustable
    4. Collapsable


IRREGULAR. CURVE
NO.21
3/4
3/4
3/4
3/4
1
1 1/8 N.C.-7-2
1 1/8
1R/2
2 3/4
2 11/16
2 1/8
2
2 5/8
2 7/16
LEFT HAND THREADS
RIGHT HAND THREADS
45°
2
5 1/2
9 1/2
2
4 1/2
4 1/2

THE PURPOSE OF THIS SHEET IS TO SHOW THE APPLICATION OF RIGHT AND LEFT HAND THREADS ON A TURNBUCKLE.
TO TELL WHETHER A THREAD IS RIGHT-HAND OR LEFT-HAND, IMAGINE YOURSELF LOOKING AT THE THREADED PIECE FROM THE END IF WHEN THE THREAD IS FOLLOWED AROUND THE PIECE GOES IN THE SAME DIRECTION THAT THE HANDS OF THE CLOCK TRAVELS OR CLOCKWISE AND IT GOES AWAY FROM YOU IT IS A RIGHT-HAND THREAD WHEN IT GOES IN THE OPPOSITE DIRECTION TO THAT OF THE HANDS OF THE CLOCK OR COUNTER-CLOCKWISE AND IT GOES AWAY FROM YOU IT IS LEFT HAND. THE SKETCH AT THE RIGHT SHOWS RIGHT AND LEFT-HAND THREADS.
A TURNBUCKLE IS A COUPLING THREADED SO AS TO REGULATE TENSION IN THE RODS WHICH IT CONNECTS.

A. COUNTER CLOCKWISE-LEFT HAND-THREAD
B. CLOCKWISE RIGHT HAND THREAD



LESSON 23

TURNBUCKLE

TOOLS AND EQUIPMENT

Drawing Board
T Square
Pencil
Drawing Paper
Drawing Instrument
Scale

MATERIALS

Drafting Material

OPERATING POINTS

1. Obtain from part print:
   a. Dimension to be gaged
   b. Limits of dimension to be gaged

2. Make size of "Go" plug lower limit of part - .0000, - .0002

3. Make size of "No Go" plug upper limit of part -.0002, - .0000

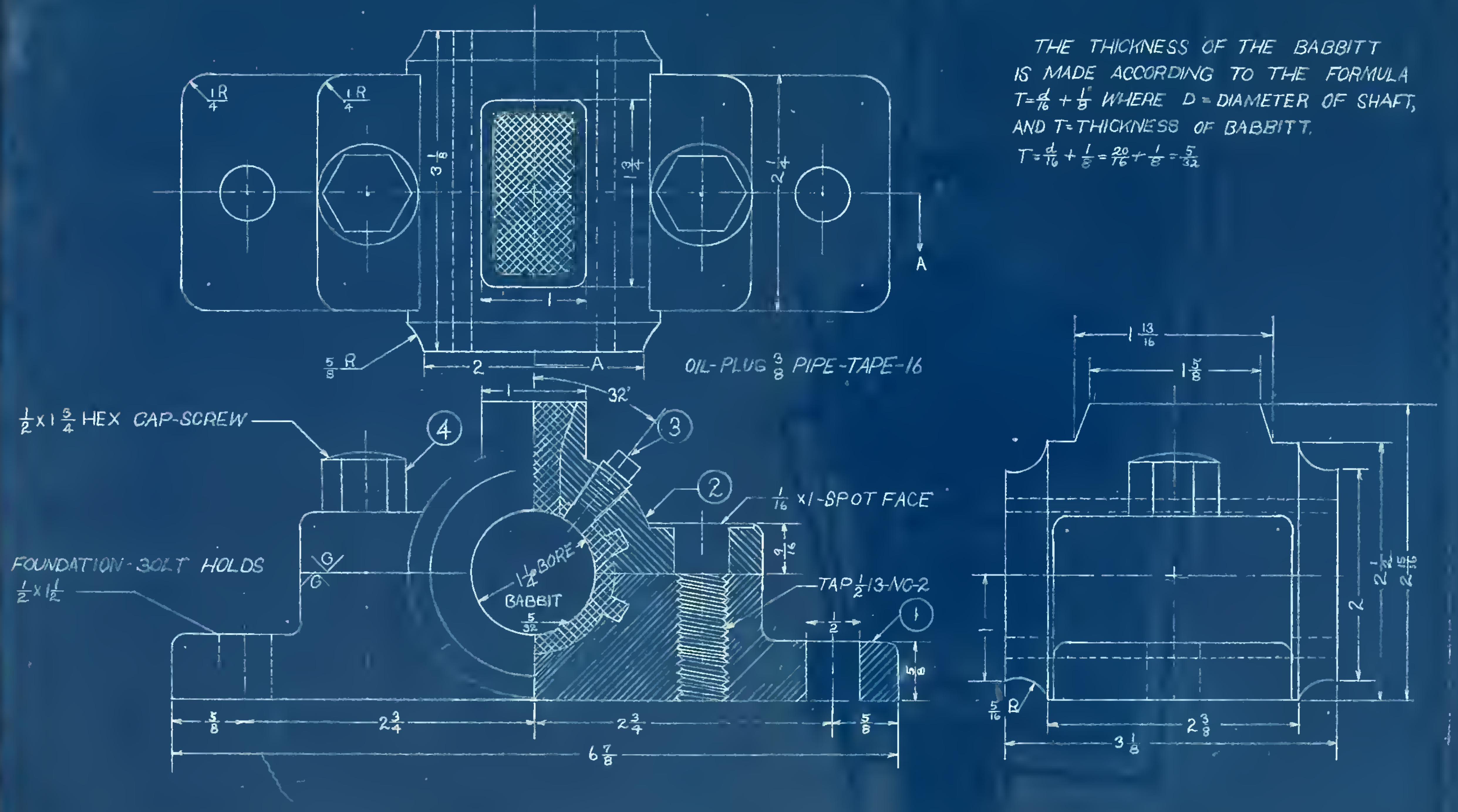
4. Reverse procedure for a snap gage

RELATED INFORMATION

1. Irregular curves

2. Threads forms standard

NO	PART	REQ	MAT.
1	BASE	1	CI
2	CAP	1	CI
3	OIL CAP PLUG	1	CI
4	THRU BOLT	2	CI


1/4 R
1/4 R
3 1/8
1 3/4
2 1/4
1
A
5/8 R
2
A
OIL-PLUG 3/8 PIPE-TAPE-16
1/2 x 1 3/4 HEX CAP-SCREW
1
32'
4
3
2
1/16 x 1-SPOT FACE
9/16
FOUNDATION-BOLT HOLDS 1/2 x 1 1/2
G
G
1 1/4 BORE
BABBIT
5/32
TAP 1/2-13-NC-2
1/2
1
5/8
5/8
2 3/4
2 3/4
5/8
6 7/8
1 13/16
1 5/8
2 1/2
2 15/16
2
1
5/16 R
3 1/8
2 3/8

THE THICKNESS OF THE BABBITT IS MADE ACCORDING TO THE FORMULA $T=\frac{d}{16}+\frac{1''}{8}$ WHERE D = DIAMETER OF SHAFT, AND T=THICKNESS OF BABBITT.

$T=\frac{d}{16}+\frac{1}{8}=\frac{20}{16}+\frac{1}{8}=\frac{5}{32}$

LESSON 24

PILLOW BLOCKS

TOOLS AND EQUIPMENT

Drawing Board
T Square
Pencil
Drawing Paper
Drawing Instrument
Scale

MATERIALS

Drafting Materials

OPERATING POINTS

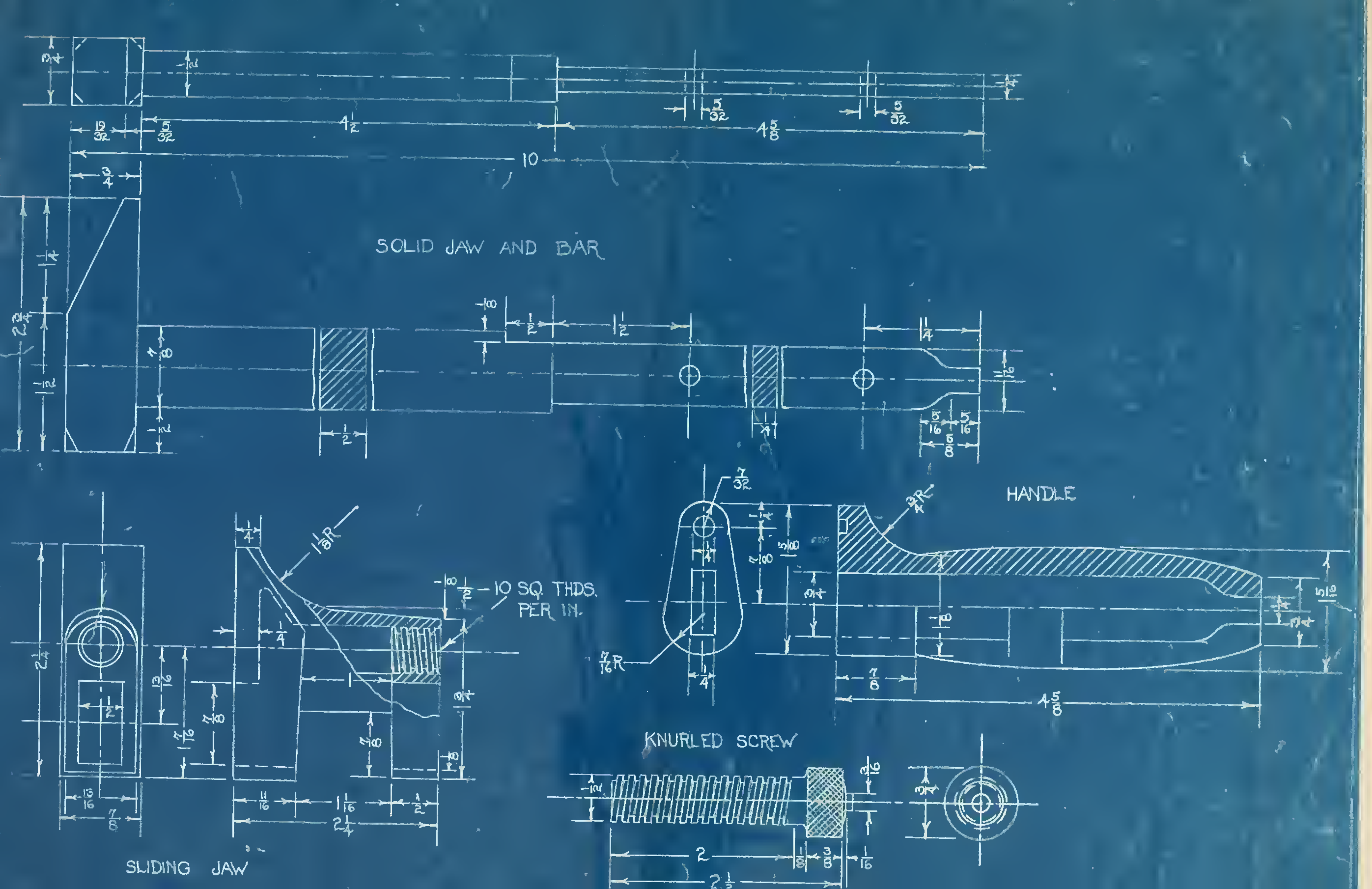
1. Indicating machine tools
2. Properties of metals
3. Cast iron brass bronze

RELATED INFORMATION

A. Types of screws
  1. Socket head
  2. Set screws
    a. Headless
    b. Square head
      (1) Points

Cup	Cone
Oval	Full dog
Flat	Half dog

  3. Hexagon head
  4. Flat head
  5. Round head
  6. Fillister head


SOLID JAW AND BAR
10
4 1/2
4 5/8
HANDLE
4 5/8
KNURLED SCREW
2
2 1/2
SLIDING JAW
10 SQ. THDS. PER IN.
1 1/8 R
7/16 R
2 1/4

LESSON 25

MONKEY WRENCH

TOOLS AND EQUIPMENT

Drawing Board
T Square
Pencil
Drawing Paper
Scale

MATERIALS

Drafting Materials

OPERATING POINTS

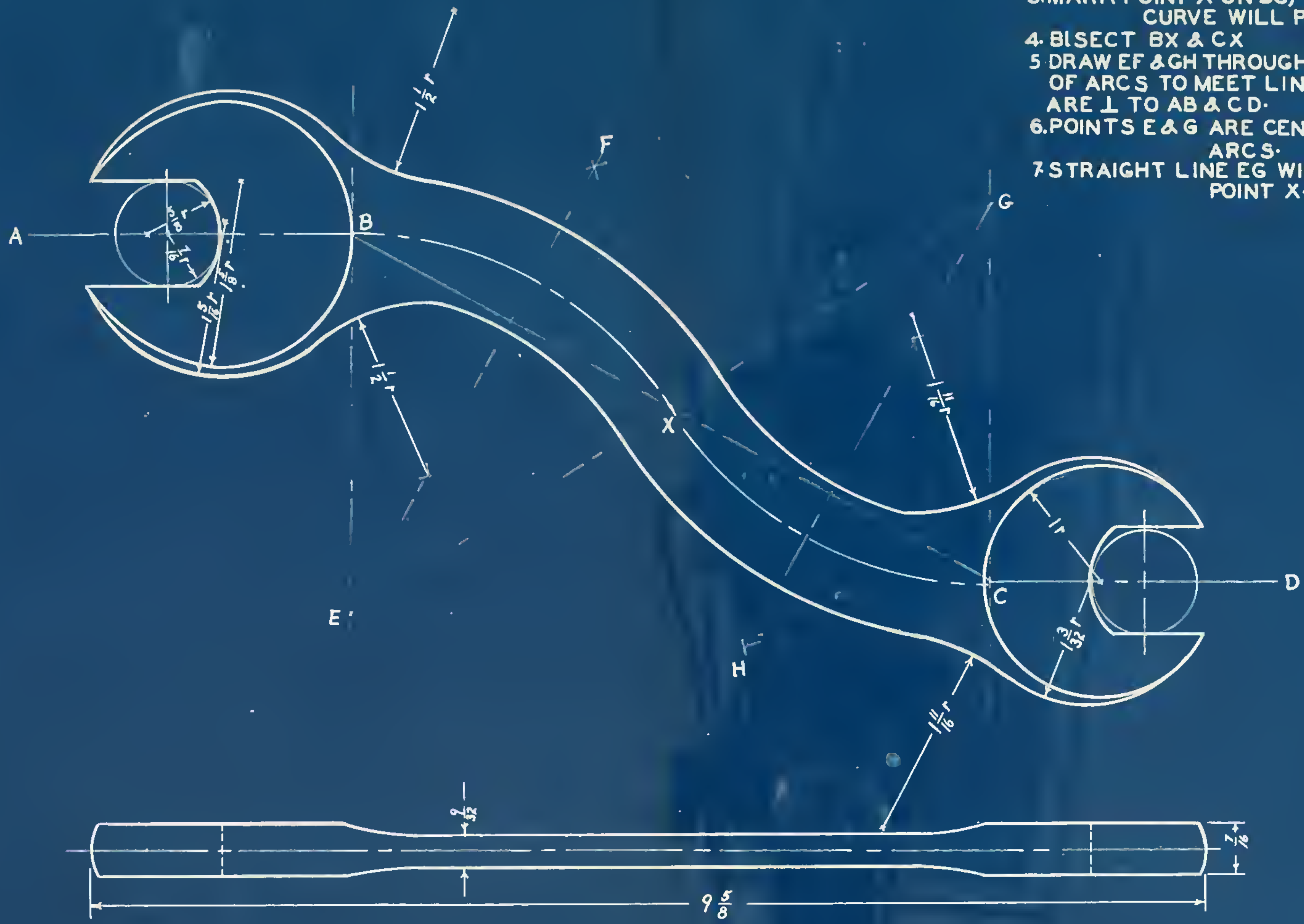
1. Layout views of part--red auxiliary lines
2. Design and layout jig or fixture around part
3. Give necessary assembly dimensions
4. Assign details number
5. List standard details in Bill of Material
6. List commercial tools in upper right corner of sheet

RELATED INFORMATION

1. Arranging for fittings
2. Methods of finishing
3. Lathe

OGEE OR REVERSE CURVE

1. DRAW 2 PARALEEL LINES AB & CD
2. DRAW STRAIGHT LINE BC
3. MARK POINT X ON BC, THROUGH WHICH CURVE WILL PASS.
4. BISECT BX & CX
5. DRAW EF & GH THROUGH INTERSECTIONS OF ARCS TO MEET LINES BE & CG, WHICH ARE ⊥ TO AB & CD.
6. POINTS E & G ARE CENTERS OF DESIRED ARCS.
7. STRAIGHT LINE EG WILL PASS THROUGH POINT X.



LESSON 26

S WRENCH

TOOLS AND EQUIPMENT

Drawing Board
T Square
Pencil
Drawing Paper
Drawing Instrument
Scale

MATERIALS

Drafting Materials

OPERATING POINTS

1. Using notations for left thread

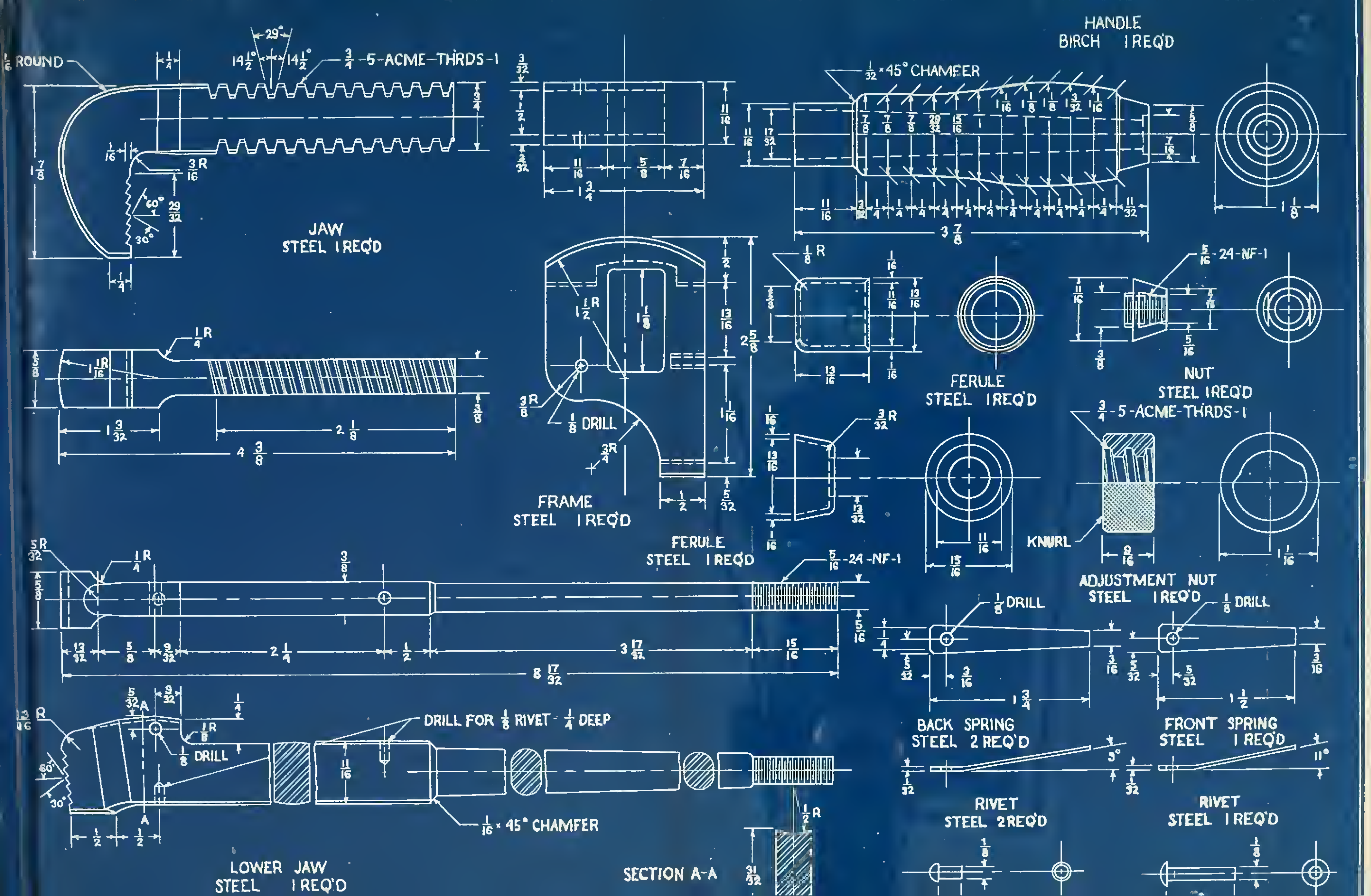
2. Methods of finishing

3. Miller

RELATED INFORMATION

A. Types of Heat Treatment
  1. Normalizing
  2. Case Hardening
    a. Case Carburizing
    b. Pack Hardening
    c. Cyaniding
    d. Nitriding
  3. Water Hardening
  4. Oil Hardening

B. Selection of Heat treatment
  1. Depends on use of part, material, and hardness desired
C. Types of hardness specification
  1. Scleroscope
  2. Brinell
  3. Rockwell
  4. Vickers


JAW
STEEL 1 REQ'D
¾-5-ACME-THRDS-1
29°
14½°
ROUND
HANDLE
BIRCH 1 REQ'D
$\frac{1}{32}$ × 45° CHAMFER
FRAME
STEEL 1 REQ'D
⅛ DRILL
FERULE
STEEL 1 REQ'D
NUT
STEEL 1REQ'D
$\frac{5}{16}$-24-NF-1
KNURL
ADJUSTMENT NUT
STEEL 1 REQ'D
⅛ DRILL
BACK SPRING
STEEL 2 REQ'D
FRONT SPRING
STEEL 1 REQ'D
RIVET
STEEL 2REQ'D
RIVET
STEEL 1 REQ'D
DRILL FOR ⅛ RIVET - ¼ DEEP
$\frac{1}{16}$ × 45° CHAMFER
LOWER JAW
STEEL 1 REQ'D
SECTION A-A
60°
30°

LESSON 27

STILLSON WRENCH

TOOLS AND EQUIPMENT

Drawing Board
T Squars
Pencil
Drawing paper
Drawing Instrument
Scale

MATERIALS
Drafting Materials

OPERATING POINTS

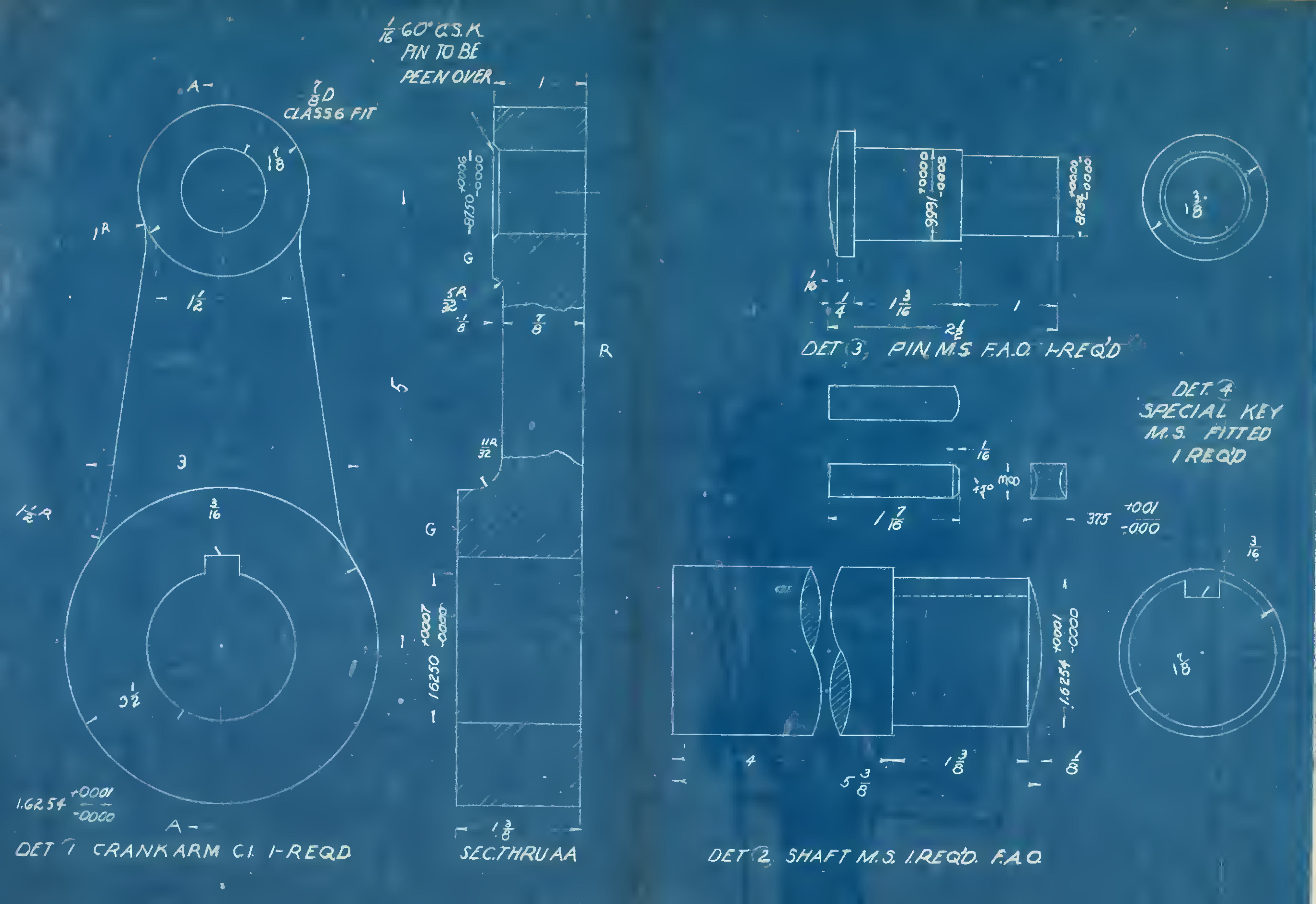
1. Detailing

2. Methods of finishing

3. Grinder

RELATED INFORMATION

1. Layout hole to be broached
2. Layout pitch of teeth
3. Layout land (1/32 max.)
4. Layout cutting clearance angle(20-30
5. Layout chip clearance angle (depending on pitch)
6. Layout rake angle (50-80)
7. Layout shank to fit puller


1/16 60° C.S.K.
PIN TO BE
PEEN OVER
A
7/8 D
CLASS 6 FIT
1/8
1R
1 1/2
3
1 1/2 R
3/16
3 1/2
1.6254 +.0001 -.0000
A
DET 1 CRANK ARM C.I. 1-REQ'D
.8750 +.0006 -.0000
G
5/32 R
1/8
7/8
R
11/32 R
G
1.6250 +.0007 -.0000
1 3/8
SEC. THRU AA
.9991 +.0000 -.0008
.8754 +.0000 -.0000
1/16
1/4
1 3/16
1
2 1/2
DET 3 PIN M.S. F.A.O. 1-REQ'D
1 3/8
DET 4
SPECIAL KEY
M.S. FITTED
1 REQ'D
1/16
45°
1 7/16
.375 +.001 -.000
3/16
1.6254 +.0001 -.0000
4
5 3/8
1 3/8
1/8
1 5/8
DET 2 SHAFT M.S. 1 REQ'D. F.A.O.

LESSON 28

OPERATION

ENGINE CRANK

TOOLS AND EQUIPMENT
- Drawing Board
- T Square
- Pencil
- Drawing Paper
- Drawing Instrument
- Scale

MATERIALS

Drafting Materials

OPERATING POINTS

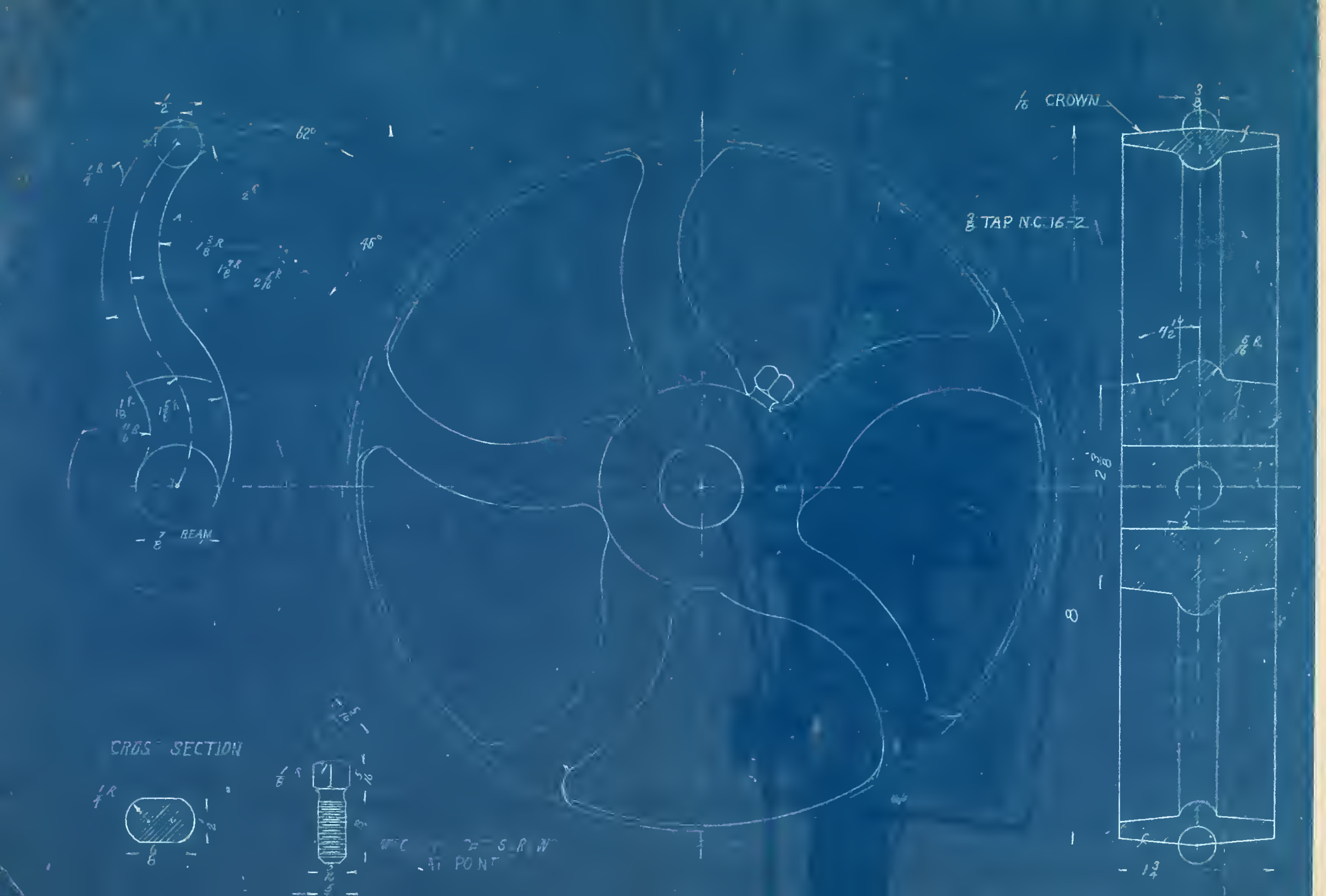
1.. Indicating round breaks

2.. Methods of finishing

3.. Foundry

RELATED INFORMATION

A. Types of Fits
  1. Running
    a. Light
    b. Sliding
    c. Push
  2. Press
    a.. Easy Driving
    b. Close
    c.. Forced
B.. Points of consideration when specifying fits
  1.. Size of part
  2.. Length of part
  3.. Type and hardness of metal
  4.. Use of practical limits



1/16 CROWN
3/8 TAP N.C. 16-2
62°
45°
REAM
CROSS SECTION
8

LESSON 29

FIVE ARM PULLEY

TOOLS AND EQUIPMENT

- Drawing Board
- T Square
- Pencil
- Drawing Paper
- Drawing Instrument
- Scale

MATERIALS

- Drafting materials

OPERATING POINTS

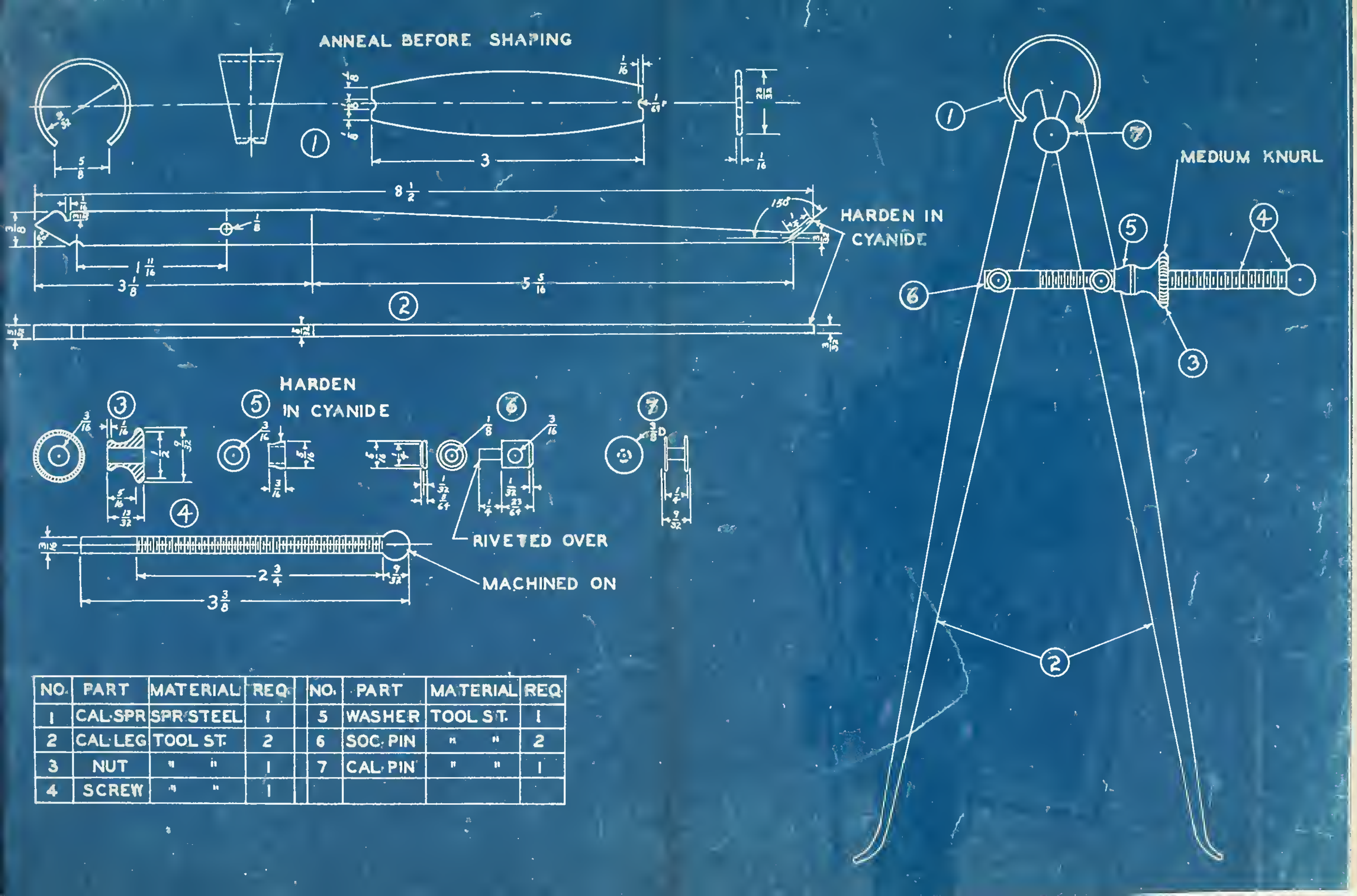
1. Half section view

2. Methods of finishing

3. Drop forging

RELATED INFORMATION

A. Types of keys
   1. Gib-head
   2. Woodruff
   3. Square
   4. Flat
   5. Kennedy
      a. Single
      b. Double


ANNEAL BEFORE SHAPING
HARDEN IN CYANIDE
HARDEN IN CYANIDE
MEDIUM KNURL
RIVETED OVER
MACHINED ON
8 1/2
3 1/8
5 5/16
1 11/16
3
2 3/4
3 3/8
150°
①
②
③
④
⑤
⑥
⑦

NO.	PART	MATERIAL	REQ	NO.	PART	MATERIAL	REQ
1	CAL·SPR	SPR·STEEL	1	5	WASHER	TOOL ST.	1
2	CAL·LEG	TOOL ST.	2	6	SOC·PIN	" "	2
3	NUT	" "	1	7	CAL·PIN	" "	1
4	SCREW	" "	1				

LESSON 30

OPERATION

INSIDE CALIPERS

TOOLS AND EQUIPMENT

Drawing Board
T Square
Pencil
Drawing Paper
Drawing Instrument

MATERIALS

Drafting Materials

OPERATING POINTS

1.. Indication types of material treatment

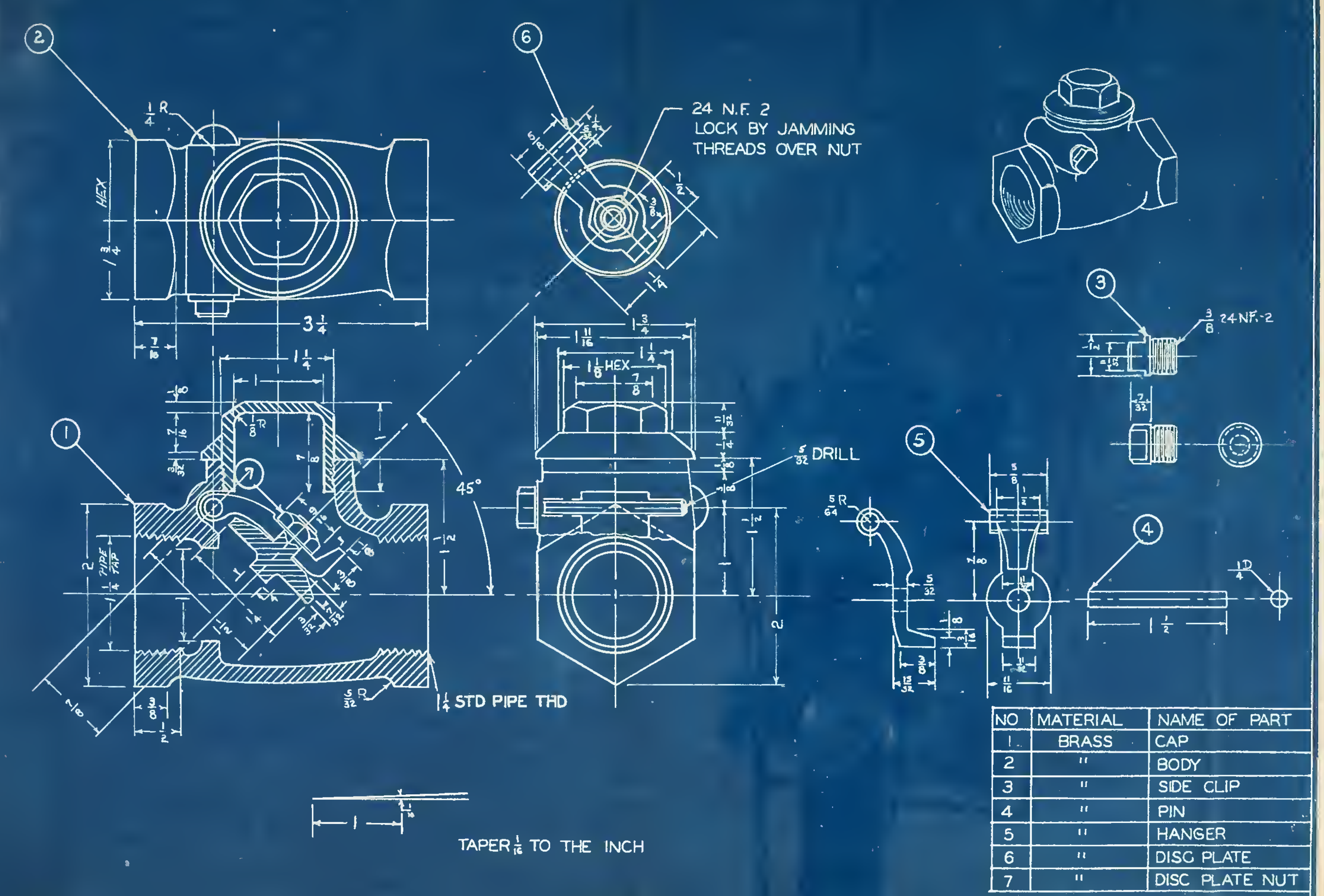
2. Methods of finishing

3. Drill Press

RELATED INFORMATION

A. Allied occupations
  1. Machine designing
  2. Tool making
  3. Die making
  4. Machine repair
  5.. Tool engineering
  6. Production control

B. Related occupations
  1. Die design
  2. Time and motion study
  3. Sales engineering
  4. Experimental engineering


②
1/4 R
HEX
1 3/4
3 1/4
7/16
⑥
24 N.F. 2
LOCK BY JAMMING
THREADS OVER NUT
1/2
1 1/4
1 3/4
1 11/16
1 1/4
1 1/8 HEX
7/8
5/32 DRILL
①
⑦
45°
2
1 1/4 PIPE TAP
1 1/2
2
5/32 R
1 1/4 STD PIPE THD
3/8
1/2
TAPER 1/16 TO THE INCH
③
3/8 24 NF-2
7/32
⑤
5/64 R
5/8
5/32
11/16
13/32
④
1D/4
1 1/2

NO	MATERIAL	NAME OF PART
1	BRASS	CAP
2	"	BODY
3	"	SIDE CLIP
4	"	PIN
5	"	HANGER
6	"	DISC PLATE
7	"	DISC PLATE NUT

LESSON 31

OPERATION

SWING CHECK VALVE

TOOLS AND EQUIPMENT

Drawing Board
T Square
Pencil
Drawing Paper
Drawing Instrument
Scale

MATERIALS

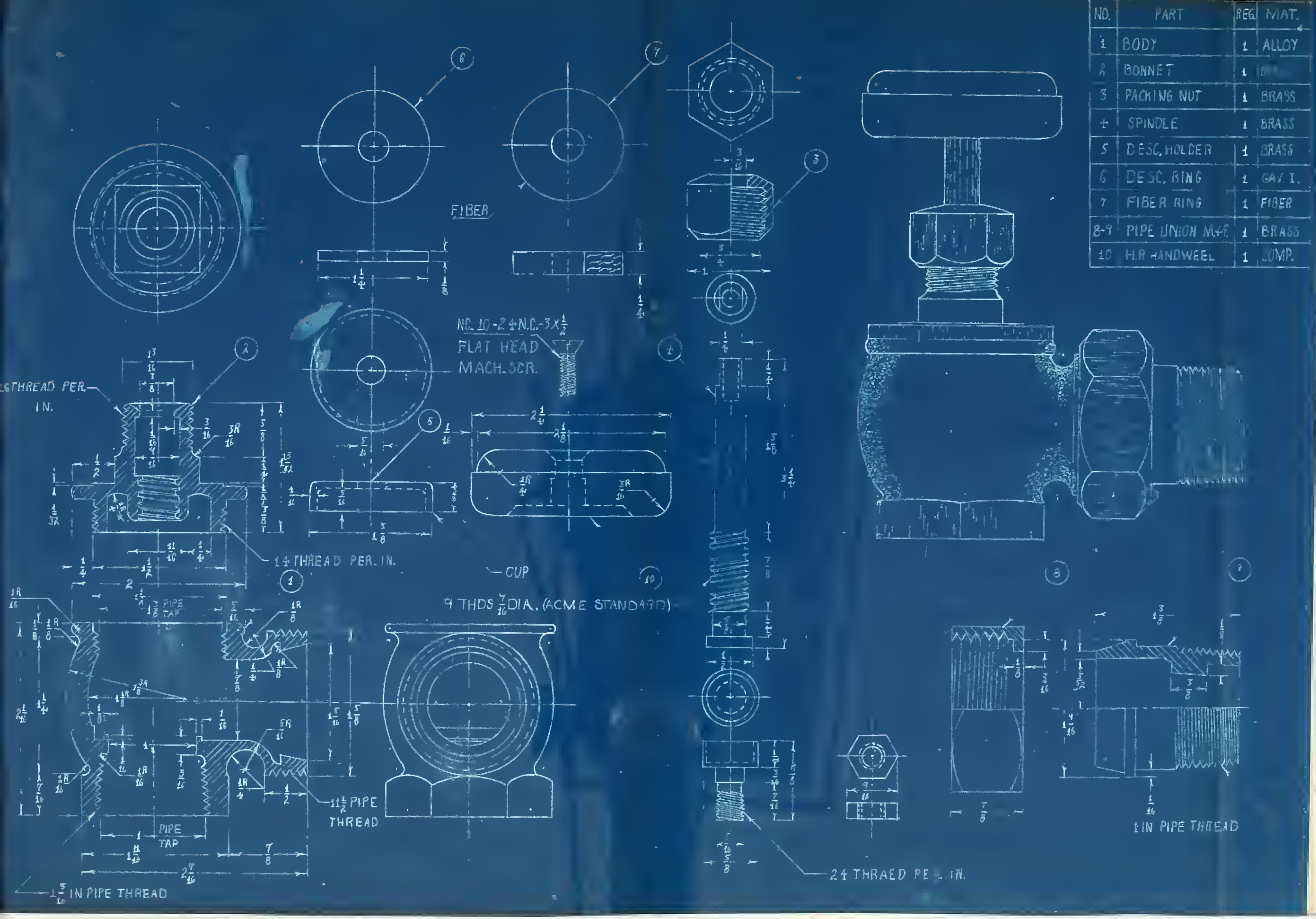
Drafting Materials

OPERATING POINTS

1. Auxiliary views
2. Selection of auxiliary

RELATED INFORMATION

1. Layout, milling fixture base
2. Layout slot in milling machine table
3. Layout key-thickness, width, length
4. Make length two or three times the width
5. Layout slot in milling fixture base
6. Layout socket head screw in key.


FIBER
NO. 10-24 N.C.-3 x $\frac{1}{2}$
FLAT HEAD
MACH. SCR.
26 THREAD PER IN.
14 THREAD PER. IN.
CUP
9 THDS $\frac{7}{16}$ DIA. (ACME STANDARD)
$1\frac{1}{2}$ PIPE TAP
PIPE TAP
$1\frac{1}{2}$ PIPE THREAD
$1\frac{5}{16}$ IN PIPE THREAD
24 THRAED PER IN.
1 IN PIPE THREAD
1
2
3
4
5
6
7
8
9
10

NO.	PART	REQ.	MAT.
1	BODY	1	ALLOY
2	BONNET	1	[illegible]
3	PACKING NUT	1	BRASS
4	SPINDLE	1	BRASS
5	DESC. HOLDER	1	BRASS
6	DESC. RING	1	GAV. I.
7	FIBER RING	1	FIBER
8-9	PIPE UNION M+F.	1	BRASS
10	H.R. HANDWEEL	1	COMP.

LESSON 32

STEAM RADIATOR VALVE

TOOLS AND EQUIPMENT

Drawing Board
T Square
Pencil
Drawing Paper
Drawing Instrument
Scale

MATERIALS

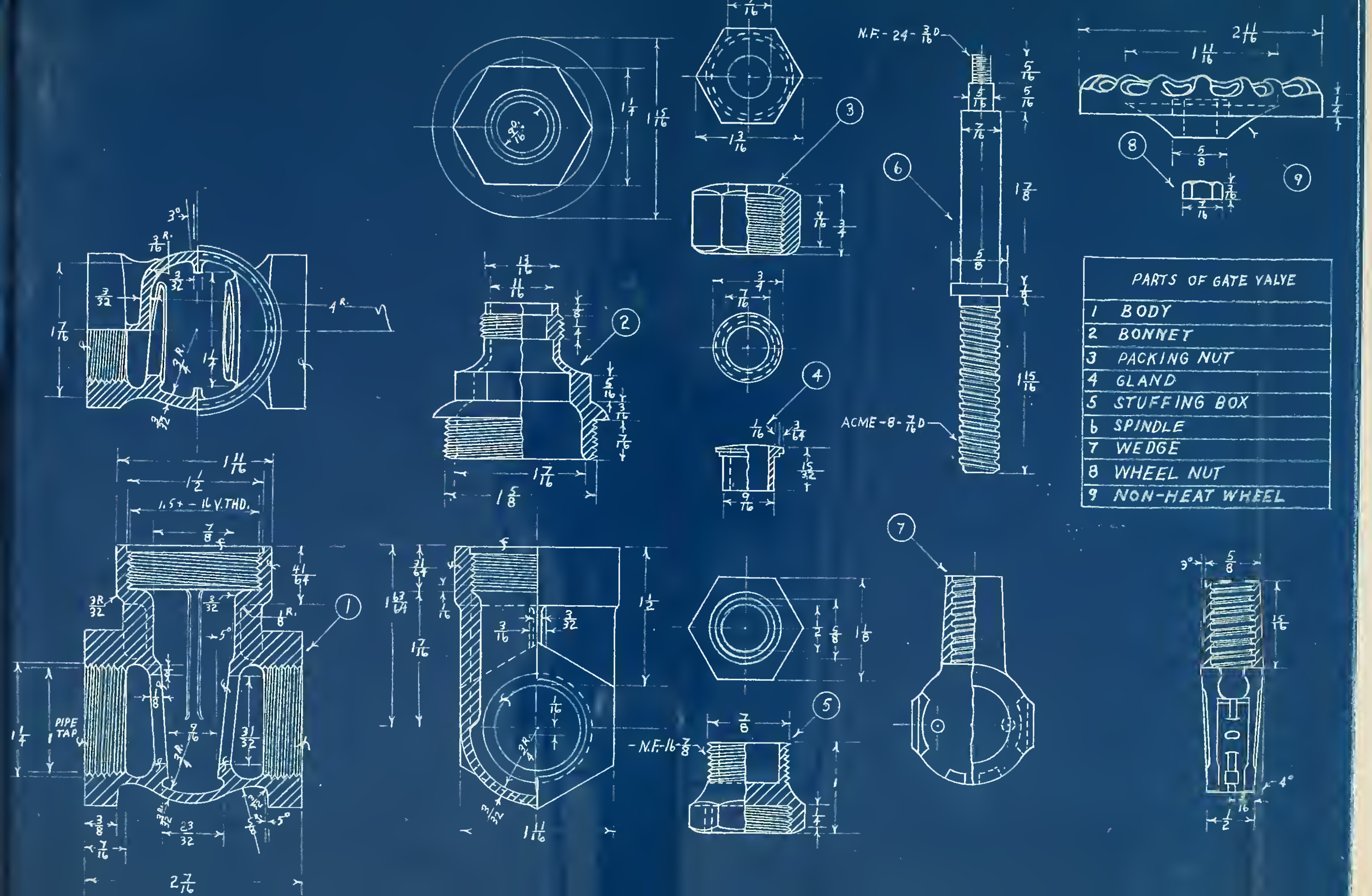
Drafting Materials

OPERATING POINTS

1. Acme threads
2. Pipe threads

RELATED INFORMATION

1. Quanity of production
2. Accuracy required
3. Material of which part is made
4. Machine in which jig of fixture is to be used
5. Previous operations on part
6. Loading and unloading
7. Chip clearance
8. Safety of operator
9. Locating points
10. Upkeep of jig or fixture
11. Facilities of toolroom


PARTS OF GATE VALVE
1 BODY
2 BONNET
3 PACKING NUT
4 GLAND
5 STUFFING BOX
6 SPINDLE
7 WEDGE
8 WHEEL NUT
9 NON-HEAT WHEEL
N.F.-24-3/16 D
ACME-8-7/16 D
1.5+ - 16 V.THD.
PIPE TAP
-N.F.-16-7/8
1
2
3
4
5
6
7
8
9

LESSON 33

DETAILS GATE VALVE

TOOLS AND EQUIPMENT

Drawing Board
T Square
Pencil
Drawing Paper
Drawing Instruments
Scale

MATERIALS

Drafting Materials

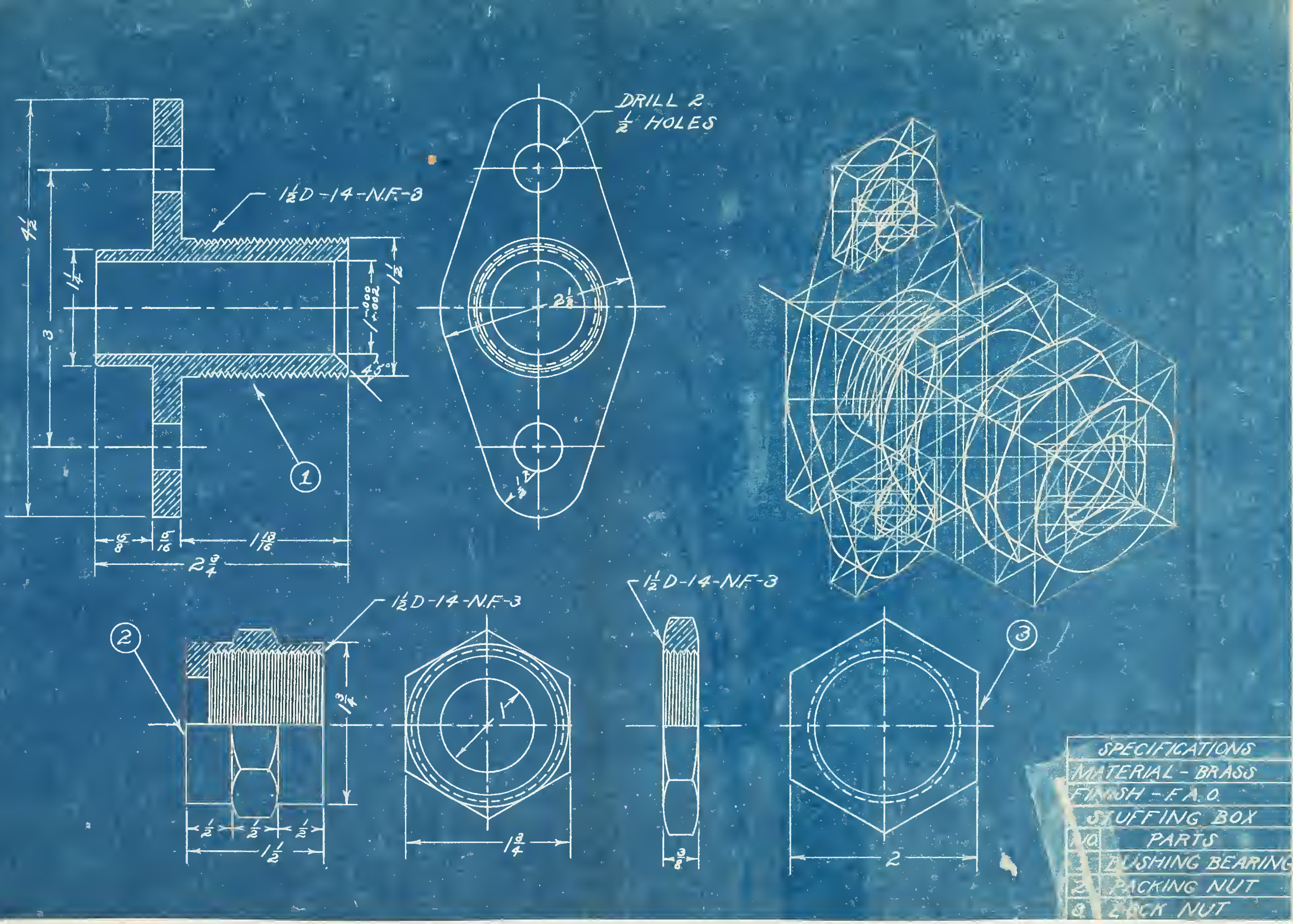
OPERATING POINTS

1. Quarter section

2. Pattern making

RELATED INFORMATION

A. Points to be considered
   1. Parts should be considered
   2. Amount of tolerance depends on
      a. Limits specified on part
      b. Size and shape of part
      c. Type and hardness of metal
      d. Use of part
   3. Desired dimension should be given-tolerance should be specified up or down.


DRILL 2
½ HOLES
1½D-14-N.F.-3
4½
3
1¼
1.000 -.002
1½
45°
2⅛
①
⅝
5/16
1 13/16
2¾
②
1½D-14-N.F.-3
1¾
½
½
½
1½
1
1¾
1½D-14-N.F.-3
⅜
③
2
SPECIFICATIONS
MATERIAL - BRASS
FINISH - F.A.O.
STUFFING BOX
NO. PARTS
1 BUSHING BEARIN
2 PACKING NUT
3 LOCK NUT

LESSON 34

STUFFING BOX

TOOLS AND EQUIPMENT

- Drawing Board
- T Square
- Pencil
- Drawing Paper
- Drawing Instrument
- Scale

MATERIALS

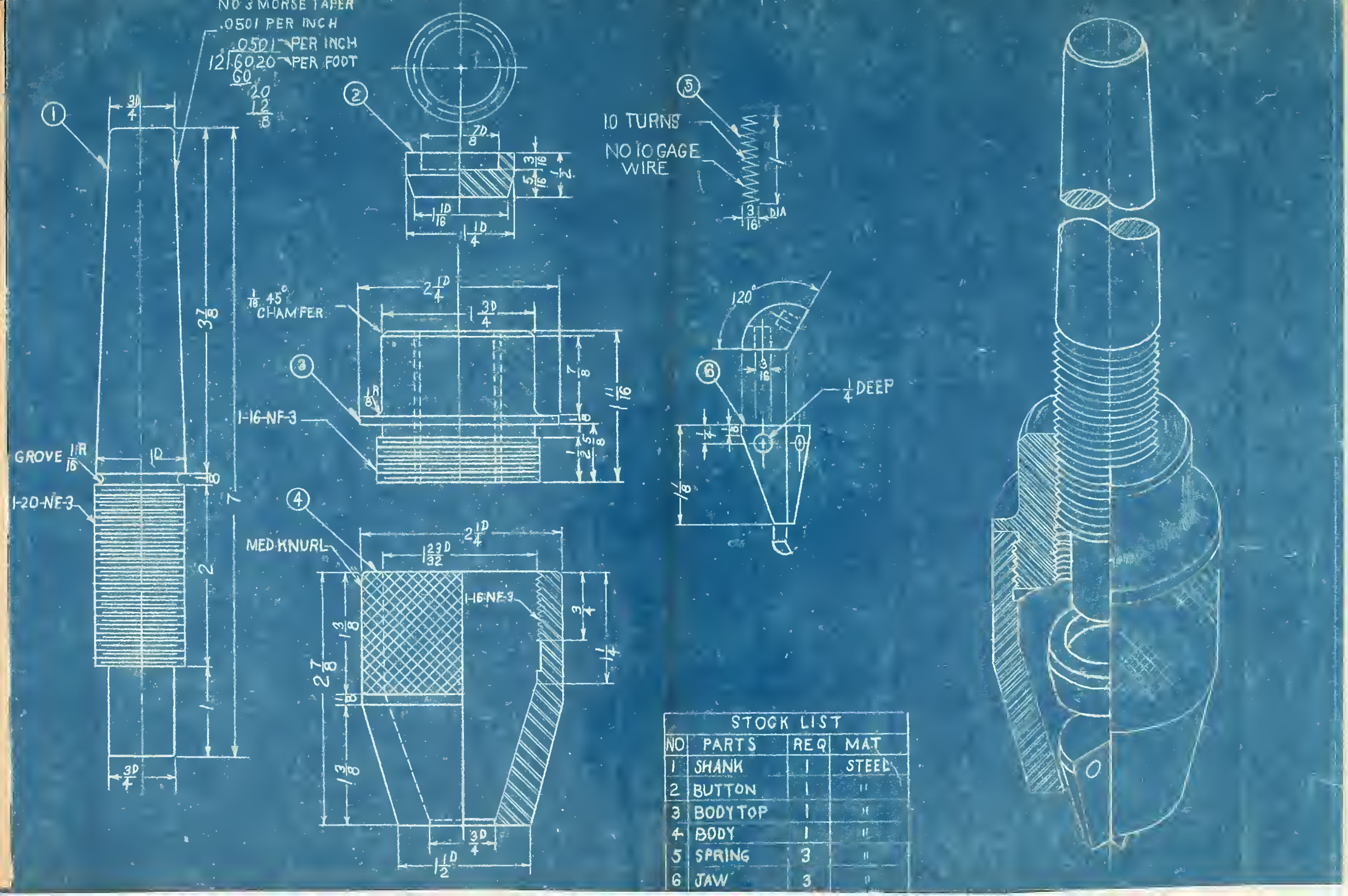
- Drafting Materials

OPERATING POINTS

1. Layout hole in part
2. Layout body diameter
3. Layout shoulder
4. Layout shank--plain or threaded
5. Layout reliefs-on body
6. Layout undercuts

RELATED INFORMATION

1. Indicating brass materials
2. Foundry


NO 3 MORSE TAPER
.0501 PER INCH
.0501 PER INCH
12 | .6020 PER FOOT
1
2
3
4
5
6
3/4 D
7/8 D
3/16
5/16
1/2
1 1/16 D
1 1/4 D
10 TURNS
NO 10 GAGE WIRE
1
3/16 DIA
3 7/8
7
2
1
1/16 45° CHAMFER
2 1/4 D
1 3/4 D
7/8
1 1/16
1/8 R
1-16-NF-3
1/8
5/8
1 1/4
120°
3/16
1/4 DEEP
1/4
1/8
1 1/8
GROVE 1/16 R
1 D
1/16
1-20-NF-3
MED KNURL
2 1/4 D
1 23/32 D
1-16-NF-3
3/4
1 1/4
1 3/8
2 7/8
1/8
1 3/8
3/4 D
1 1/2 D
3/4 D

STOCK LIST

NO	PARTS	REQ	MAT
1	SHANK	1	STEEL
2	BUTTON	1	"
3	BODY TOP	1	"
4	BODY	1	"
5	SPRING	3	"
6	JAW	3	"

LESSON 35

DRILL CHUCK

TOOLS AND EQUIPMENT

- Drawing Board
- T Square
- Pencil
- Drawing Paper
- Drawing Instrument
- Scale

MATERIALS

- Drafting Materials

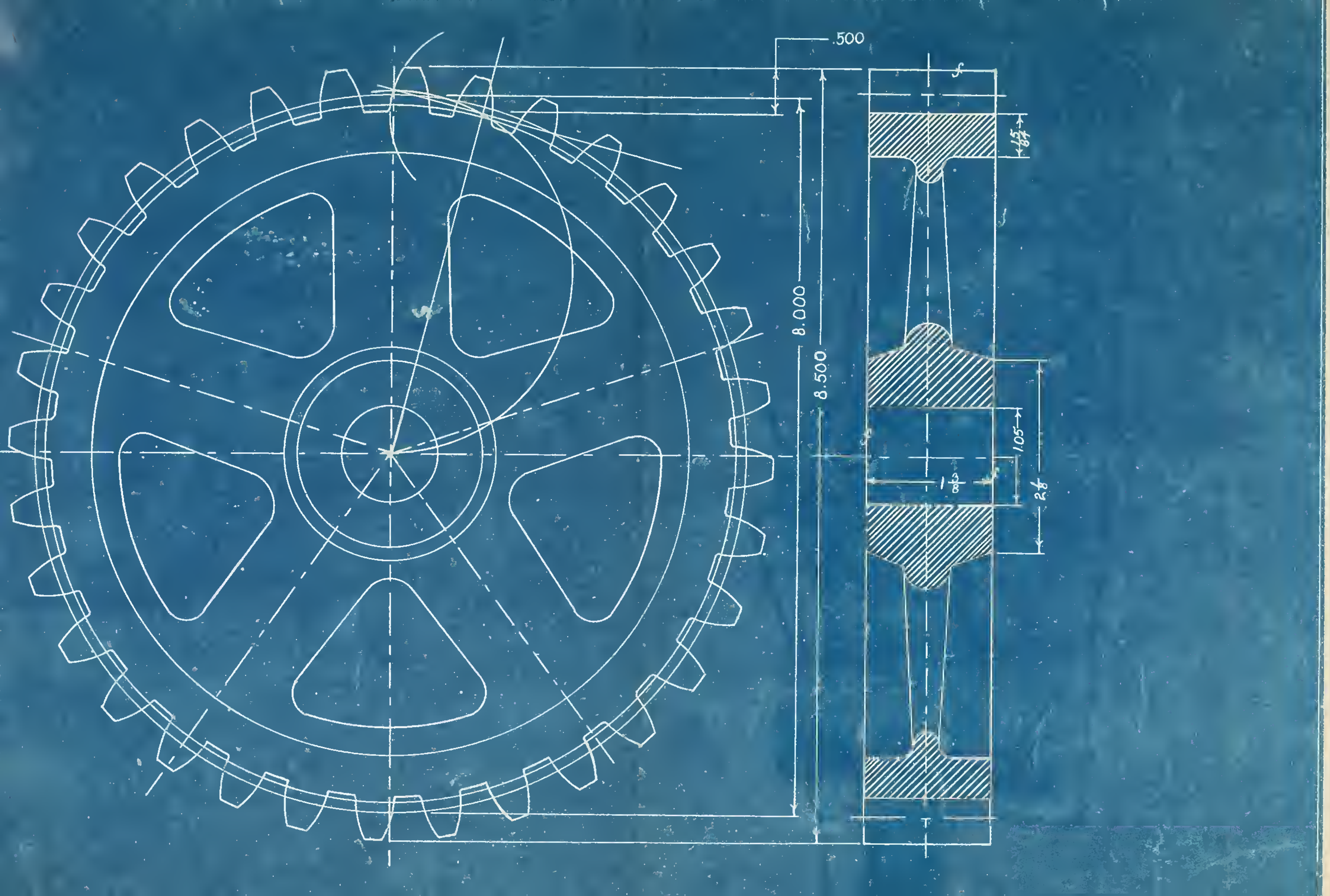
OPERATING POINTS

1. Conventional threads
2. Standard tapers

RELATED INFORMATION

A. Tapers

   1. American
   2. Brown & Sharpe
   3. Jarno
   4. Morse
   5. Jacobs (for chucks)



LESSON 36

SPUR GEAR

TOOLS AND EQUIPMENT

- Drawing Board
- T Square
- Pencil
- Drawing Paper
- Drawing Instrument
- Scale

MATERIALS

- Drafting Materials

OPERATING POINTS

1. Designing gear blanks
2. Gear nomenclature
3. Method of Calculating Gears

RELATED INFORMATION

A. Types of Gears
    1. Spur
    2. Bevel
    3.. Internal
    4. Hëlical
    5. Heringbone
    6. Elliptical
    7. Worm
    8. Hypoid

B. Gear Cutting Machines
    1. Form Disc
    2. Multiple
    3. Shaper
        a. Vertical
        b. Horizontal
    4. Generator
    5. Hobber
    6. Copying planer
    7. Bevel planer
    8. Spiral bevel generator

PART III

Test

Part 1 35-2 points 70
Part 2 24-$1\frac{1}{4}$ points 30
100

Name
(Last Name) (First Name)

Score

Directions: Underscore the statement which makes the best answer. Only one answer is correct. Answer each question, as your score is based upon the number of questions which you answer correctly.

1. The best pencil to make a sketch with is: (1) HB; (2) 6H; (3) 4H; (4) 6B; (5) 4B.

2. The proper pencil to use in making a mechanical drawing is (1) 3B; (2) 4H; (3) HB; (4) 9H; (5) 4B.

3. The term 4H printed on a pencil means the pencil is: (1) hard; (2) soft; (3) medium; (4) of good quality; (5) very soft.

4. The drawing pencil is sharpened with a chisel point so: (1) it will draw a straight line; (2) the point will not get dull quickly (3) it will draw dark lines; (4) curved lines can be drawn; (5) arrowheads can be made easily.

5. In making a sketch: (1) a pencil, scale, and eraser should be used; (2) a pencil, rule, and eraser should be used; (3) a pencil, eraser, and T square should be used; (4) a pencil, eraser, and compass should be used; (5) all of the drawing instruments may be used.

6. If a sketch is in proportion it means that: (1) the sketch is in the center of the paper; (2) all lines are straight; (3) all parts are of the proper relative size; (4) the sketch is made with the proper pencil; (5) the sketch has three views.

7. An oblique drawing is: (1) a drawing with slanting lines; (2) an isometric drawing; (3) a mechanical drawing; (4) any three-view drawing with oblique lines; (5) a picture drawing.

8. The oblique lines of an isometric drawing are made at an angle to the horizontal of: (1) 30 degrees; (2) 45 degrees; (3) 60 degrees (4) 90 degrees; (5) $17\frac{1}{2}$ degrees.

9. Isometric drawings are used because: (1) they are easy to read; (2) they are easy to make; (3) they show all the hidden parts; (4) they take up less space than a three-view drawing; (5) mechanics prefer to work from them

10. All lines on a mechanical drawing should be: (1) light: (2) dark; (3) medium; (4) thin; (5) thick.

11. The T square is used by a right-handed person with the head on: (1) the left side of the drawing board; (2) the right side of the drawing board; (3) the bottom of the drawing board; (4) the top of the drawing board; (5) either side.

12. Horizontal lines on a drawing are drawn by a person who uses his right hand: (1) from right to left; (2) from left to right; (3) either way; (4) usually from right to left but sometimes the opposite way; (5) half to the left and half to the right.

13. To draw a vertical line use: (1) a T square; (2) a triangle; (3) an architect's scale; (4) a T square and triangle; (5) two triangles.

14. Border lines should be made: (1) light; (2) medium; (3) dark; (4) thick; (5) either dark or medium.

15. Every circle shown on a drawing should have: (1) one center line; (2) two center lines; (3) three center lines; (4) no center lines; (5) an odd number of center lines.

16. A bow pen is: (1) a pen used in lettering; (2) a pen used to draw straight lines; (3) a pen used to draw curved lines; (4) a compass used to draw small ink circles; (5) a pen used when a French curve is used.

17. In inking a drawing which has circles, horizontal lines, and vertical lines (1) ink the horizontal lines first, the vertical lines second, and the circles last; (2) ink the vertical lines first, the horizontal lines second, and the circles last; (3) ink the circles first, the vertical lines second, and the horizontal lines last; (4) ink the horizontal lines first, the circles second, and the vertical lines last.

18. For in work, the pen used to draw straight lines is called: (1) bow pen; (2) crow quill pen; (3) ruling pen; (4) drop pen; (5) contour pen.

19. To do good lettering: (1) light lettering guide lines should be drawn; (2) fine lettering guide lines should be drawn; (3) no guide lines need be drawn; (4) dotted guide lines should be drawn; (5) either dark or light guide lines may be drawn.

20. Most mechanical drawings, have: (1) one view; (2) two views; (3) three views; (4) four views; (5) five views.

21. In a three-view drawing, the top view is placed: (1) over the side view; (2) below the side view; (3) to the left of the front view; (4) to the right of the front view; (5) above the front view.

22. To understand a mechanical drawing, it is necessary to examine: (1) the top view; (2) the front view; (3) the side view; (4) any single view; (5) all the views given.

23. A mechanic prefers a mechanical drawing to guide him in his work instead of a picture drawing because: (1) anyone can understand a mechanical drawing; (2) a mechanical drawing is cheaper; (3) a mechanical drawing shows the proper size and shape of every part of the object; (4) a mechanic cannot read a picture drawing; (5) a picture drawing shows more than the mechanic needs to know about the object.

24. In a circle there are: (1) 100 degrees; (2) 180 degrees; (3) 90 degrees; (4) 360 degrees; (5) 45 degrees.

25. The term "2 inch circle" means: (1) the radius of the circle is 2 inches; (2) the diameter of the circle is 2 inches; (3) the circumference of the circle is 2 inches; (4) the chord of the circle is 2 inches; (5) the diameter of the circle is 1 inch.

26. When a dimension is placed near a view, the space between the dimension and the view should be at least: (1) 1/16 in.; (2) 1/8 in.; (3) 1/4 in.; (4) 3/8 in.; (5) ½ in.

27. To stagger dimensions means: (1) to place them in line with each other; (2) to place one above the other; (3) to place them between views; (4) to place them upside down; (5) to place them on opposite sides of a center line.

28. Arrowheads on dimension lines should be made: (1) freehand; (2) with a triangle; (3) with a scale; (4) with the T square held in a slanting position; (5) with a bow pencil.

29. Sectional views are most commonly used on: (1) square objects; (2) cylindrical objects; (3) rectangular objects; (4) picture drawings; (5) pattern developments.

30. A scale is used; (1) to draw horizontal lines; (2) to measure; (3) as a straight edge; (4) to draw vertical lines; (5) to draw border lines.

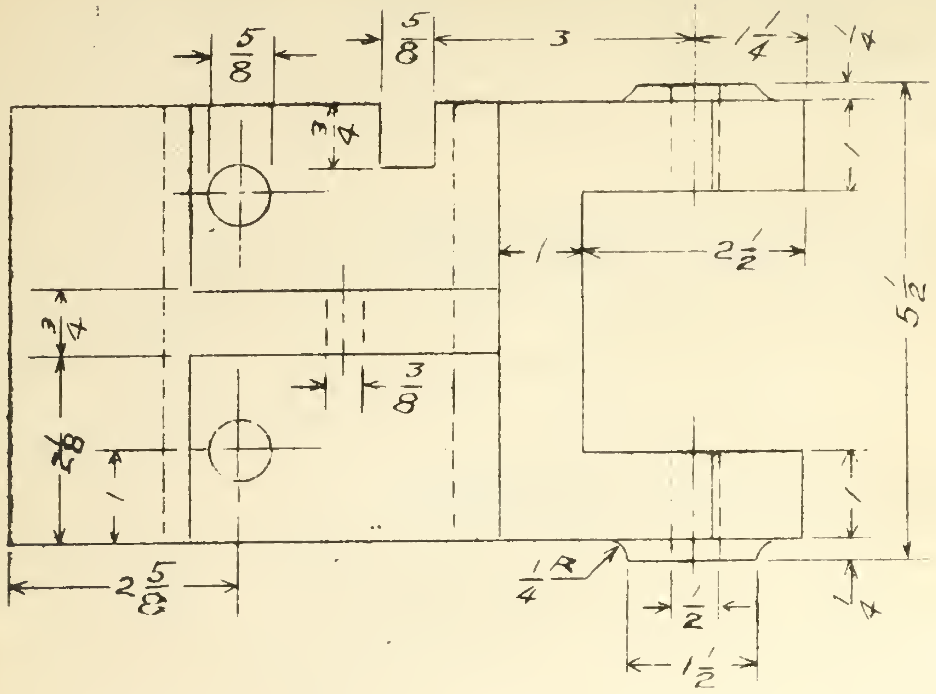
31. If the scale of a drawing is half size, the dimensions given on the drawing are: (1) the size of the object; (2) the size of the drawing; (3) one half the size of the drawing; (4) one half the size of the object; (5) two times the size of the object.

32. Fillets are used on machine parts: (1) to make the metal cool quicker when the object is cast; (2) to make them easier to draw; (3) to make them look better; (4) to save metal; (5) to make them stronger.

33. A blueprint is best made from: (1) a sketch; (2) an ink tracing; (3) a pencil drawing; (4) a pencil tracing; (5) an ink drawing.

34. The term "a tapped hole" means: (1) a square hold; (2) a hole which is threaded inside; (3) a hole made with a drill; (4) a hole which does not go all the way through the object; (5) a hole made with a punch.

35. In using a French curve, it is necessary to connect at least: (1) two points at a time; (2) three points at a time; (3) four points at a time; (4) five points at a time; (5) any number of points may be connected at one time.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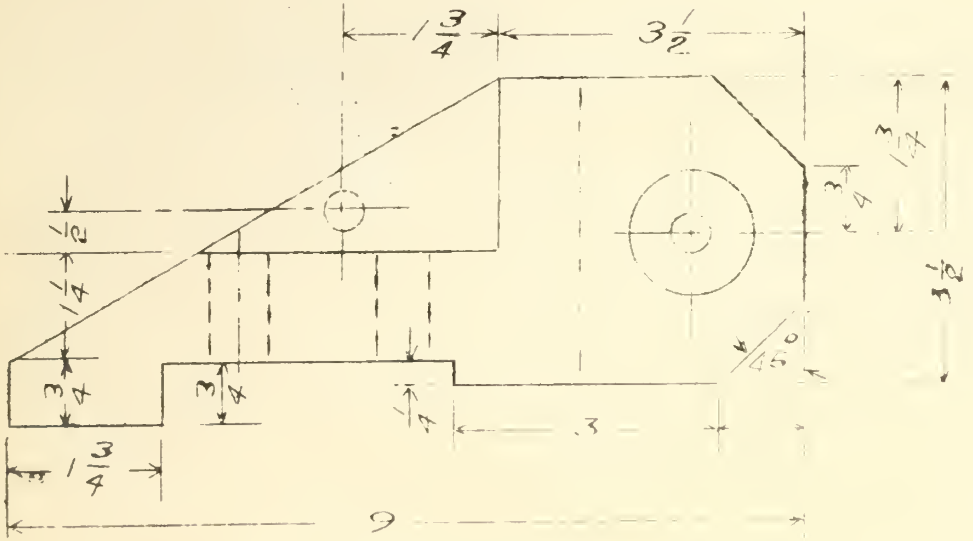
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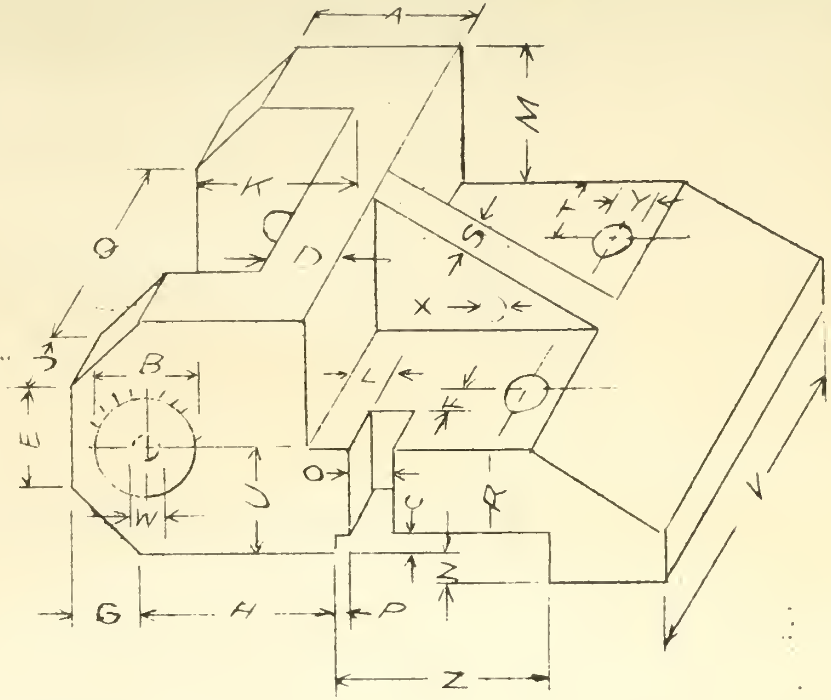
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V

PROBLEM

FIND THE MISSING DIMENSIONS FROM A TO Z, OMITTING I. List them alphabetically.

A
B
C
D
E
F
G
H
I
J
K
L

O
P
Q
R
S
T
U
V
W
X
Y
Z

KEY TO FINAL QUIZ

Part I

Question	Answer
1	1
2	2
3	1
4	2
5	2
6	3
7	5
8	1
9	1
10	4
11	1
12	2
13	4
14	5
15	2
16	4
17	3
18	3
19	1
20	3
21	5
22	5
23	3
24	4
25	2
26	3
27	5
28	1
29	2
30	2
31	1
32	5
33	2
34	2
35	2

Part II

	Answer
A	2¼
B	1½
C	¼
D	1
E	1¼
F	¼
G	1
H	1
J	1
K	2½
L	3/4
M	2
N	½
O	5/8
P	¼
Q	3
R	1¼
S	3/4
T	1
U	1 3/4
V	5
W	½
X	3/8
Y	5/8
Z	3½

PART IV

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